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A Companion to Chomsky

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NICHOLAS ALLOTT, TERJE LOHNDAL, AND GEORGES REY

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A Companion to Chomsky

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1

Synoptic Introduction

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1.1 Introduction

Noam Chomsky is justly famous for his revolutionary contributions to linguistics, psychology and philosophy. He is in his 93rd year, and we thought it high time to provide an overview of the major achievements of his now more than 60-year-old research program and its prospects for the future. This is particularly pressing in the light of persistent rumors, encouraged by a number of authors[1], that his program has proven bankrupt, "completely wrong," and has been replaced by various sorts of proposals in general statistical learning and "functionalist/constructionist" linguistic theories (to which we return below).

We think these rumors are seriously mistaken. To be sure, the theory has evolved, displaying the kinds of complexities, revisions and increasing depth typical of any ongoing science. However, Chomsky's ideas and those of others working in his "generativist" framework are at the center of much of the most successful current work on the grammar of human language, and his work has been influential across many other areas of linguistics, including research on processing, language acquisition, language diversity and semantics. His program is one of the most important in the history of linguistics, and it has profound and enduring significance for psychology and philosophy, and indeed for our understanding of human nature generally.

This volume brings together views of Chomsky's legacy from the perspectives of many of his program's foremost practitioners, as well as some of his critics, in the many specific areas his work has influenced, including syntax, semantics, pragmatics, psycholinguistics and language acquisition, as well as philosophy of language, mind and science. It is divided into sections that address the main aspects of his work, each of which we will briefly summarize in this introduction.

Chomsky is, of course, also famous for his political writings. It is important to stress that these bear no direct connection to his linguistics, and lack of space here ruled out

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an entire section that would begin to do them justice. But we have at the end included one excellent and unusual discussion by Joshua Cohen and Joel Rogers of some of the enlightenment ideas that seem to inform both the politics and the linguistics.

All the chapters here are intended to be accessible to people not expert in the topics of the papers. All should be readable by linguists, philosophers, psychologists, and the general public interested in the present status of Chomsky's work in the many areas we have mentioned. Therefore, they do not presuppose extensive technical knowledge of linguistics, although since the papers are short, some do get more technical toward the end.

1.2 Part I: Historical Development of Linguistics

A key feature of Chomsky's work on grammar, present from the beginning, is its concern to explain how, on the basis of exposure to a finite set of utterances, we come to be able to produce and understand a potential infinity of sentences we've never encountered (Chomsky 1955, p. 61; 1957, p. 15). Note the obvious but (when you think about it) remarkable fact that most sentences anyone encounters they have never heard before, and that the potential infinity is systematic, allowing some clauses and other constituents to be nested indefinitely, as, for example, in *This is the cat that chased the mouse that . . . . lived in the house that Jack built* but not *Cat Jack mouse the in is lived house chased*.

In his (1955) and (1957), where he developed an explicit and rigorous framework for analyzing the syntactic structure of human languages generally, Chomsky proposed that the potential infinity of sentences should be accounted for by the system of rules being "recursive" i.e. they can take their own output as input, thus building up structures of arbitrary complexity. In this framework, sentences are not just words that are linearly ordered, but instead, have abstract hierarchical structure.[2] He postulated two types of rules: "phrase structure" rules that construct (or "generate") the underlying structures, and transformational rules that operate on the structures thus generated and (inter alia) explain relations between sentences with related meanings: e.g. between the declarative *Eagles can fly* and the related polar interrogative *Can eagles fly?*[3]

Chomsky (1957) illustrated the need to postulate hierarchical structure and transformations that operate on it with a ground-breaking analysis of the English auxiliary system. Consider how English polar interrogatives are formed.[4] The auxiliary *can* in *Eagles can fly* "moves" to the beginning of the sentence, yielding *Can eagles fly?* English is strict about polar interrogatives starting with an auxiliary. When the declarative doesn't have one – e.g. *Eagles fly* – the "dummy" auxiliary *do* is inserted to satisfy the rule, so the interrogative here is *Do eagles fly?*

But what about more complex sentences with embedded clauses, such as *Eagles that fly swim,* where *Eagles that fly* is the subject? The related interrogative is *Do eagles that fly swim?* And even if you've never read this sentence before, you know (after a moment's thought, perhaps) that it is a question about whether a certain type of eagle (the flying type) swims and it *cannot* be understood as a question about whether swimming eagles fly. That is, the question auxiliary, *do*, is somehow connected to the verb *swim*, not the verb *fly*. If a sentence is just a list of words, this is hard to explain. Why should *do* be connected to the verb *swim*, which is further away than *fly*?

If we see sentences as hierarchical structures, then the answer is obvious. The structure of *Eagles that fly swim* is:

(1) [[Eagles [that fly]] swim]

That is, the sentence is made up of a subject [*Eagles that fly*] combined with a verb [*swim*], and the subject also has internal structure: it is made up of the noun *eagles* followed by a relative clause [*that fly*]. And then the rule for making a polar interrogative is just that the auxiliary *do* can only question the *main* verb in the clause (here *swim*), not a verb embedded in the subject like *fly*. In somewhat intuitive terms, we can say that *fly* is too deeply embedded to be "visible" to the rule that forms the interrogative. Equally, we can say that despite the misleading appearance given by linear order, *swim* is actually "closer" to the auxiliary, because the kind of closeness that matters is closeness *in the hierarchical structure*, and *swim* is at the top level, easy to access for a rule that operates on the declarative as a whole structure.

Thus, an adequate theory of English polar interrogatives has to postulate that sentences have hierarchical structure and that syntactic rules are sensitive to this structure (i.e. they are "structure-dependent"). There's nothing special about English or auxiliaries, though. In effect, all the work done by Chomsky and other generativists on syntax of many languages rests on these assumptions, and its continued, cumulative success has by now made it clear that all human languages have hierarchical structure and structure-dependent grammatical rules.

Chomsky's interest in the formal aspects of grammars led him to organize formal grammars themselves into a hierarchy, today known as either the Chomsky hierarchy or the Chomsky-Schützenberger hierarchy (Chomsky & Schützenberger 1963). Tim Hunter's chapter (Chapter 5) provides an extensive introduction to this hierarchy and also discusses its application to human languages, a central research objective in formal linguistics ever since Chomsky's fundamental work on this topic.

However, Chomsky himself quite quickly turned away from this purely formal interest, and from around 1960 began to pursue in print what he always regarded as the more fundamental questions concerning the human ability to acquire and use language, which he proposed was due to a faculty of Universal Grammar (UG).[5] UG is the name for whatever innate mechanisms humans are born with which are specific to language ability and which enable them to acquire language. What they acquire includes an internal grammar (their I-language in the current terminology) that is characterized in terms of the kind of recursive rule system mentioned above, thus explaining the ability of a finite brain to produce and understand a potential infinity of novel sentences.

One kind of striking phenomenon that can serve as a useful introduction to Chomsky's psychological theories in this regard are what he sometimes calls "fine thoughts," or what we will call "WhyNots." These are strings of words that native speakers of a language find unacceptable, even though they can pretty readily guess what someone could mean by them: they would seem to express "perfectly fine thoughts" (cf. Chomsky 1962, p. 531; 2013a, p. 41; 2015, p. 98). Innumerable examples can be found in the literature, but one particular sort is interesting because it appears to be indisputably universal, i.e., true of all human languages.[6]

Consider the perfectly reasonable English sentence that a child might hear, *Mommy and Daddy will feed Fido*. Now, someone unsure of hearing this sentence could ask the

"echo" questions, *Mommy and Daddy will feed* ***who****?* or *Mommy and* ***who*** *will feed Fido?*, and in any language like English that moves interrogative (or *wh*-) words, they could also ask the first one by asking, *Who will Mommy and Daddy feed?* But, curiously, in no language in which the interrogative could be moved, could they ask the second one by: **Who will Mommy and feed Fido?* Indeed, in no language can one extract an interrogative from a conjunction.[7]

The question for linguistics is: *Why not?* Surely no one ever teaches a child such a rule. Nor does such a rule seem to be merely a tacit convention, since alternatives to it never occur. Indeed, it's extremely unlikely that the child ever hears or tries to produce such a sentence. It's hard to resist the suggestion that Chomsky pursued on the basis of this and innumerable similar phenomena that human children are somehow innately constrained to form some but not others of a potential infinity of strings of words. And Chomsky's main proposal at this stage was that these constraints could and should be capturable by formal and explicit theories of grammatical structure of the sort he had studied earlier, but which are in some way or another the result of innate features of the human brain.

The chapters included in this first section are as follows. In Chapter 3, Artemis Alexiadou and Terje Lohndal provide an answer for two questions about generative grammar: Where are we now? And how did we get there? They explain how the Principles and Parameters approach emerged from early Phrase Structure grammars of the 1950s and 1960s. They also set out the underlying ideas leading to Government and Binding (GB) theory and later to the current Minimalist Program, alongside identifying some prominent contemporary areas of research.

Lisa Lai-Sheng Cheng and James Griffiths (Chapter 4) consider some enduring discoveries that the Chomskyan program of research has contributed, focusing on empirically supported assertions relating to nonlocal dependencies and the explanatory role of gaps or empty categories. The generalizations they discuss are cross-linguistically robust, which also means that they serve as useful diagnostic tools.

As already mentioned, Hunter (Chapter 5) provides an introduction to the Chomsky hierarchy, and a review of recent discussions of it. He focuses on the key intuitions from this highly mathematical work and how they can be applied to theoretical linguistics. Notably, Hunter argues that the lasting contributions of the Chomsky hierarchy are more significant than previous assessments would suggest.

Chomsky has mostly worked on syntax, but in a groundbreaking study of the sound patterns of English, Chomsky and Morris Halle (1968) launched a new framework for phonology construed as the study of the mental representations of speech sounds, which, like those of syntax, also turn out to have complex structure. This book was enormously influential and led to a great deal of cross-linguistic work based on the general approach Chomsky and Halle developed. In Chapter 6, Charles Reiss and Veno Volenec argue that, notwithstanding its status as a landmark in phonology, some of its most important implications have been neglected by the field, and remain to be exploited.

In the last chapter in this section (Chapter 7), Lila Gleitman offers a personal and historical perspective on how Chomsky's work engages with and fits into cognitive science more generally, in particular in experimental work on language acquisition. She explains how her initial prejudice in favor of non-nativism – i.e., that children learn the vast bulk of their linguistic knowledge from the input they receive – was challenged at every stage by her experimental findings.

1.3 Part II: Contemporary Issues in Syntax

Over the past 70 years, since the work that led up to his (1951) MA thesis on Hebrew[8], Chomsky has developed and revised his ideas, sometimes radically, often in reaction to work that emerged in the large community of linguists working within the generative framework. As Alexiadou and Lohndal's chapter makes clear, the differences from one period to another may be quite substantial, yet the core questions that are being addressed are often rather similar. Each new path attracted new students and scholars, but some scholars also decided to stick to the previous path (cf. Sells 1985). As such, the new ideas have also led to a rather dynamic community, and sometimes controversy as to what is the best way forward.

Often, the theory has been developed based on a small set of data (e.g., so-called "expletive" constructions in English such as *There were many students in her class/It is raining today,* where the *There* and *It* are semantically vacuous). But then the theory makes numerous predictions about other areas of the grammar that can then be tested and, as a result, the theory is often revised. This is just normal science, in which theories are frequently revised and sometimes replaced as new evidence is considered and greater depth achieved.

Some opponents of Chomsky have criticized him for being too focused on English, or for not caring enough about the coverage of data from the thousands of the world's languages. Apart from his master's thesis on Hebrew, it is fair to say that Chomsky has not personally worked on a large number of languages. However, generativists have pursued comparative syntax across languages from many different families from Amharic to Zoque – including both spoken and sign languages (see e.g. Lasnik and Lohndal 2013; Allott and Rey 2017). This work was one of the considerations that led directly to the Principles and Parameters approach, which proposes that UG is a combination of fixed principles and variable parameters – e.g. whether a verb precedes its direct object or *vice versa* – which are set during language acquisition on the basis of what the child hears. In fact, as Mark Baker's chapter makes clear, Chomsky's work has contributed significantly to the study of linguistic diversity.

Of course, the languages of the world at least superficially appear to vary widely. Appreciating the cross-linguistic evidence, using it to triangulate on UG, and to show how, despite the diversity of superficial appearances, all these languages plausibly do respect UG, requires careful analyses of the expressions in these languages – just as appreciating the underlying unities in any domain requires analyses beyond surface appearances (as in biology, chemistry, physics – who would have thought that ice and steam are the same substance?).

The present section covers multiple topics that all relate to contemporary issues in syntax. In Chapter 8, David Adger deals with the nature of hierarchical relations, in particular the computational procedure needed to generate such relations. In contemporary parlance, this operation is called Merge, and it has become a hallmark of the program, partly also because of Chomsky's suggestion that Merge may be one of the evolutionary novelties that enabled humans to develop language. Adger is concerned with what kind of computing device this is, and among others, he discusses the relationship between the abstract specification of a function and procedures to compute it.

Adger's chapter also prepares the ground for Peter Svenonius's chapter, Chapter 9, which discusses Merge and syntactic features, collectively described as "the engine of syntax." Minimalism has pursued Chomsky's (1995b) proposal that the grammatical

operations themselves are very simple, but that they operate on lexical items (e.g., morphemes, such as words and suffixes) that may have a range of individual features that are the basis of a complex grammar. A great deal of research has been devoted to determining the class of these possible features across human languages, their character (are they binary or multivalent, for example), and the relationships and possible interdependences between them. Svenonius provides an overview of some ways in which this pursuit has been carried out, focusing in particular on the operations not only of Merge, but also "Agree," which governs the interaction between different kinds of features.

As we've mentioned, language variation has always been important to Chomsky's program, leading to the emergence of the Principles and Parameters theory in the late 1970s. In Chapter 10, Baker discusses the importance of linguistic diversity in Chomsky's work, as described above. Baker divides Chomsky's career into three different phases, using three influential books as representatives of each phase.

In Chapter 11, Michelle Sheehan probes the issue further in discussing Chomsky's influence on the modelling of linguistic variation, in particular work that has suggested some kind of parametric approach to language variation. Originally, this approach assumed that linguistic variation was pretty much like a "switchboard" where the task of acquiring syntax was confined to determining the correct setting for each property listed on the switchboard. This model has undergone substantial changes, which Sheehan discusses alongside objections to the very concept of parameters.

As Cheng and Griffiths' chapter in Part I made clear, one of the enduring discoveries of the Chomskyan research program is the restrictions it proposed on non-local dependencies, such as those involved in *wh*-movement, where, as we saw above, the movement of *wh*- words out of a conjunction is barred (see also related examples (a)–(c) in fn. 4). Gereon Müller's chapter (Chapter 12) discusses these in great detail and provides an overview of the various ways in which these have been accounted for.

Chomsky's own work has mostly focused on synchronic grammatical analyses. However, his work has also inspired work on historical change mainly in the area of syntax, in particular through the realization that much language change happens through language acquisition. Chapter 13, Elly van Gelderen's chapter, provides an overview of this development, including his most recent work on labeling.

Another area where Chomsky's thinking has inspired a great deal of work is the area of second language acquisition. In Chapter 14, Roumyana Slabakova discusses ways in which work on second language acquisition has embraced theoretical developments in syntax, and how it has sometimes informed those developments as well. In recent years, work on multilingual speakers more generally has burgeoned. This research has tried to unravel the nature of mental representations in speakers who master multiple languages. Chapter 15 by Tanja Kupisch, Sergio Miguel Pereira Soares, Eloi Puig-Mayenco, and Jason Rothman puts this recent development in context and explains its importance.

1.4 Part III: Comparisons with Other Frameworks

There are, of course, many ways in which grammar can be studied. Chomsky's methodology has been remarkably influential and successful, but it is important to compare it with other perspectives. For reasons of space, we obviously could not do justice to the many perspectives in the larger field of linguistics. We have chosen comparisons

with three prominent approaches to syntax: "nonderivational," but broadly generative approaches, general statistical learning, and usage-based approaches.

A hallmark of Chomskyan approaches has always been that they are what is called "derivational," that is, that they assume that non-local dependencies are created by what is typically called movement (e.g., in *What did you eat for breakfast?*, *what* has moved from its original position as the object of the verb *eat*). However, in the late 1970s, nonderivational approaches started to emerge, where rules of grammar are stated as constraints that apply to representations, i.e. ruling that they are allowed (well-formed) or barred (ill-formed). Such approaches are often called "declarative" (sometimes "representational") as they do not have a procedural component – the grammar is not characterized in terms of derivational steps.[9] However, they share with Chomsky the goal of providing explicit and structured accounts of a well-formed expression in a given language and for any language. Chapter 16 by Peter Sells discusses three different declarative frameworks and shows in detail how they are compatible with Chomsky's early work, and then outlines their design features, and provides examples of grammatical analyses within such frameworks.

As we noted at the beginning of this introduction,another approach that is often assumed to be incompatible with Chomsky's approach is statistical learning in its many different guises. In Chapter 17, Lisa Pearl argues that this is too simplistic, and that statistical learning can both complement UG and help refine our models of its contents. Her focus is in particular on how statistical modeling provides a better understanding of how learners navigate the hypothesis space they are faced with, and she argues that within an approach that remains generative, statistical learning might even replace UG as an explanation for at least certain properties of the adult grammar and how they are acquired.

The last chapter in this section, Chapter 18, written by Frederick Newmeyer, scrutinizes differences between Chomsky's linguistics and what can broadly be labeled "usage-based linguistics." The latter is an umbrella term for a variety of approaches that share the commitment to study the *use* of language as opposed to focusing on the underlying computational systems of syntax that enable such use. This includes "constructionist" work that sees the basic units of language as grammatical constructions (e.g. active and passive) and the "functionalist" perspective that regards the use of language (primarily in communication) as a major influence on grammar. Comparing Chomsky's work to the shared commitments of usage-based linguistics is complicated by the fact that Chomsky has rarely engaged with published work in this tradition. However, Newmeyer solves this problem by selecting what he takes to be the most important issues separating the two traditions and carefully outlining the positions that they have taken on those issues.

1.5 Part IV: Processing and Acquisition

There is no doubt that Chomsky was a core member of the group that started what is often called "the cognitive revolution" (Miller 2003), which he spearheaded with his critique of B.F. Skinner (Chomsky 1959). His work ensured that linguistic competence was viewed as part of cognition and, together with developments in psychology and philosophy, that mental computations over representations came to be seen as a legitimate

and fertile area of research. In this section, we consider his legacy in two areas that we have labeled *processing* and *acquisition*.

Chapter 19 by Dave Kush and Brian Dillon explores how Chomsky's work has influenced research on one area of linguistic performance, namely sentence processing or "parsing." In particular, they carefully demonstrate with examples how grammatical theory is relevant to such research: specifically, how the theory makes predictions about the behavior of the parser.

Work on parsing and linguistic perception focusses on real time processing of language, connecting syntax with psycholinguistics. A more recent development is research into the neurolinguistic underpinnings of language, which is the topic of Emiliano Zaccarella and Patrick C. Trettenbrein's Chapter 25. In particular, they are concerned with the neural signatures of the core components of grammar as put forward in much of Chomsky's work: universal principles of grammar, constituency, recursion, and Merge. The identification of such signatures supports Chomsky's claim that language is a biological system and that his work has significant implications for the study of the neuroscience of language.

Ever since Chomsky (1959), but in particular with Chomsky (1965), language acquisition has been a vital concern when developing theories that can model humans' linguistic abilities. This, in part, arises from Chomsky's conception of language as being essentially a biological phenomenon, where facts about growth and development are often essential to the characterization of its structure: a full theory of the structure of the eye needs to include an account of how it grows. Thus, for Chomsky, a central goal of linguistic theory has been what he calls "explanatory adequacy," i.e., it must at least account for the possibility of language acquisition. And here a core argument has always been that children are born with the relevant constraints that determine the "hypothesis space" for acquiring the grammatical rules in a given language, what has traditionally been referred to as UG. In Chapter 21, Stephen Crain and Rosalind Thornton provide many examples of children's acquisition of restrictions on co-reference that demonstrate the necessity of UG for any explanatory account of child language development.

Another area where Chomsky's ideas about innateness have been important is the linguistics of the spontaneous sign languages of the deaf. In Chapter 22, Diane Lillo-Martin provides an overview of research on sign language grammar that has been inspired by Chomsky, focusing particularly on what that grammar can tell us about the innateness of linguistic abilities and cognitive modularity more generally.

The last area that this section surveys is work done on atypical acquisition. This encompasses two different types of cases: instances where there is no essential input during the early stages of acquisition, and instances where the stimulus is rich but insufficient due to some disorder. In Chapter 23 by Neil Smith and Ianthi Tsimpli, these cases are discussed in detail from the point of view of the influence of Chomsky's work. Smith and Tsimpli show that they provide invaluable evidence about the language faculty and its distinctness from and interaction with other aspects of human cognition.

1.6 Part V: Semantics, Pragmatics, and Philosophy of Language

Chomsky's work on grammar sees language as a bridge between sound and meaning, and has always aimed to explain certain facts about linguistic meaning. "Meaning," of

course, is a controversial and polysemous term, and the different entries in this section address some of the very different concerns to which it is attached.

One issue that has always been central to generative grammar is why certain readings of sentences are and others are not possible for certain sentences. For example, why can *The man called the woman from Montana* mean "The man called the woman, who was from Montana," and "The man called, from Montana, the woman," but not "The man, who was from Montana, called the woman"? And why are superficially very similar sentences understood so differently (*John is easy to please* entails *It is easy to please John*, but *John is eager to please* does not entail **It is eager to please John*)? Equally, why do certain distinct strings have related or identical meanings (as with an active sentence and the related passive, for example)? Chomsky and other generativists provide answers in terms of underlying hierarchical sentence structures and constraints which explain both which structures can be generated and transformed, and how their constituents relate to each other: that is, by providing a syntactic theory. It is in this respect that generative syntax can be said to be essentially concerned with meaning.

Chomsky has, however, always opposed the widely held functionalist view of language according to which the purpose of language is communication, and the associated methodology that seeks to explain syntactic facts –which kinds of configurations of linguistic items are possible– in terms of semantic function, i.e., what they are used for. (Such views are discussed in Newmeyer's chapter in section 3.) Chomsky's view is that if language has any purpose at all, it is the expression of thought. He notes that many, indeed the vast majority of grammatical sentences, are hardly usable, because they are too long – e.g. example (2), or hard to parse (3), or combine words that are syntactically but not semantically compatible (4), for example:

(2) John and Mary and [… + two million conjuncts …] went to the party.
(3) Mice cats dogs chase bite squeak.
(4) Colorless green ideas sleep furiously.

Chomsky is, however, also skeptical about much work in linguistic semantics, in particular formal truth-conditional semantics – at least if it is taken in full metaphysical seriousness, involving commitments to extralinguistic objects, as it often is in contemporary philosophy of language – since it treats word-meanings as denotational (e.g. *water* denotes H_2O, and *London* denotes the city of that name) and sentence meanings as involving *truth* conditions. Influenced on this point by the later Wittgenstein, JL Austin and Peter Strawson among others, he argues that it is language *users* who *refer*, not the words themselves considered in abstraction from use. Sentences should not be seen as contributing to meaningful propositions that are true or false by themselves independently of usage, but rather constraints on the thoughts that they can be used to express (when used literally).

In addition to these influences from ordinary language philosophers, and Chomsky's rejection of formal semantics, his conception of grammar as a system of computations over representations has been influenced by the formal, "analytic" tradition in the philosophy of language exemplified by the work of Frege, Russell, and the early Wittgenstein, as John Collins discusses in Chapter 24. Of course, for Chomsky the formal system is intended as a description of a particular aspect of cognition, the language faculty. Collins argues that it is a significant achievement of Chomsky's to propose that "language is its own thing, an object of interest regardless of its poor design relative to

the ends to which formal systems are developed," and to show how an explicit theory of that object can be provided.

Paul Pietroski's Chapter 25 explains in some detail the centrality to generative grammar of accounting for different readings in terms of underlying structures (discussed above). He also sets out some of the currents in modern philosophy of language that Chomsky opposes, in particular the truth-conditional, referential conception of linguistic meaning found in the work of Donald Davidson and David Lewis, and Hilary Putnam's semantic externalism. He explains Chomsky's challenges to these views and shows how they point the way to an alternative, internalist conception of meaning.

In Chapter 26, Michael Glanzberg explores the influence that Chomsky has had on natural language semantics. He explains the extent and the specific targets of Chomsky's skepticism about semantics and the related issue of whether syntax is in some important sense 'autonomous' of semantics. He notes that much of the leading research on truth-conditional semantics is generativist and indebted to Chomsky's methodology in syntax. But he goes on to explain Chomsky's reasons for skepticism about the foundations of such work, which seems to him to be committed to the existence of referents of words such as *foible* and *average family*, as when we talk about "the foibles of the average family." Chomsky's point is not that it's impossible to devise workarounds for such problems, but that they suggest that, as we've already noted, the mechanisms of language in abstraction from its use don't involve *reference*, so linguistic semantics should be recast. Glanzberg also discusses what Chomsky sees as a more productive line of enquiry: the study of features within the I-language, which both have syntactic effects and encode aspects of meaning. Chomsky's suggestions here have helped to foster the now thriving field of lexical semantics.[10]

As mentioned above, Chomsky's view is that truth and reference are not properties of linguistic expressions but of speech acts performed by language users. He has also stressed what he calls "the creative aspect of language use": the ability to produce and understand sentences in ways that are appropriate to circumstances but not determined by them, an ability that is in part explained by the generative, recursive nature of human language which enables us to produce and parse an indefinite number of novel sentences. So he might be thought sympathetic to the study of communication and utterance meaning in context: linguistic pragmatics. Indeed, in the context of his skepticism about truth-conditional linguistic semantics, he says that "[i]t is possible that natural language has only syntax and pragmatics" (Chomsky 1995a, 26). But he is also skeptical about the prospects for pragmatic theory. In Chapter 27, Nicholas Allott and Deirdre Wilson examine his reasons and argue that they do not rule out systematic work. On the contrary, they claim, Chomsky's work provides a blueprint for the study of mental systems in terms of an explicit theory of their proprietary principles, and they argue that work in theoretical and experimental pragmatics implements these recommendations in investigating the system that generates interpretations for overt communicative acts.

1.7 Part VI: Cognitive Science and Philosophy of Mind

Chomsky has often said that what really underlay his interest in linguistics was his desire to understand the mind more generally, and he early on presented his views as a

resuscitation of early modern "Rationalist" views of the mind that had been rejected by the eighteenth and then twentieth-century "Empiricists." Very roughly: according to Rationalists such as Descartes and Leibniz, crucial parts of our knowledge, for example, logic and mathematics, were "innate" and could be known *a priori,* justifiable without any essential appeal to experience. Empiricists, particularly the "Logical Positivists," who flourished first in Europe and then in America from about 1925 through 1960, regarded such claims as virtually mystical, and argued that the only view of knowledge compatible with the striking successes of natural science was that it was wholly based on experience – or, in the case of logic and mathematics, on the social conventions of language; and language was known by reinforced responses to stimuli, along lines studied by the Behaviorists such as Watson and Skinner.

Chomsky (1975) explained that the notions of innateness, UG and explanatory adequacy were in the "immediate background" of his work in the 1950s (cf. fn 5), but they didn't explicitly emerge until his now famous (1959) critique of Skinner's (1957) presentation of a Behaviorist conception of language learning. From then on, particularly in his (1965, 1966, and 1968/2006), Chomsky championed specifically the Rationalist's appeal to innate ideas as a basis of knowledge, particularly of grammar (interestingly, he seldom, if ever discusses *a priori* knowledge, and certainly never claims that the principles of grammar are knowable *a priori*; and so that topic is not addressed in this volume). This resuscitation of innate ideas has been tremendously influential not only in linguistics but also in research on infant cognition (e.g., Spelke, 2003), knowledge of arithmetic (e.g., Carey, 2009), the folk theory of mind (e.g., Apperly, 2010), and moral thought (Mikhail, 2011).

In Chapter 28, Georges Rey explores the philosophical issues surrounding Chomsky's nativism, and Stephen Crain, Iain Giblin and Rosalind Thornton in Chapter 29 set out some of the extensive empirical evidence for it. Central to that evidence is what has come to be called the *poverty of the stimulus* argument: the stimuli presented to small children acquiring language are simply far too impoverished to account for the grammatical competence they acquire in only a few years, a problem Chomsky calls "Plato's problem," assimilating it to the problem Plato raised in his *Meno* about how someone untutored could come to appreciate geometry. Again, consider the "WhyNots" mentioned above: What empirical basis could lead apparently all children not to ask questions like **Who will Mommy and feed Fido?* It is hard to see an alternative to an account that posits some kind of innate state that constrains them from moving a question word from a conjunction, or, more specifically, from acquiring an internal grammar that would permit it.

A further question, of course, is how a brain with such innate knowledge could possibly have evolved, an issue that Chomsky began to address in detail in the 1990s as one of the motivations for the Minimalist program. In Chapter 30, Anne Reboul discusses Chomsky's views on language evolution, noting that he has long held that the language faculty is a biological endowment, but that it probably arose suddenly and that the core principles of language show no signs of selection pressure. In work in recent decades he proposed that the sudden transition was the arrival of Merge, allowing for the production of hierarchical structures, initially used only in thought, but later externalized in speech. Reboul argues that work on evolution of language (and thought) also needs to account for the fact that human concepts, perhaps uniquely, are "decoupled" from external stimuli and so seem to be innately constrained along the lines of a Chomskyan theory.

Behaviorists such as Skinner and (more forcefully) the influential philosophers Nelson Goodman and Willard van Orman Quine were not only skeptical of the Rationalist's appeal to innate ideas; they were even more skeptical of what they called "the idea idea" itself, and thought serious science should avoid traditional appeals to internal ("private"?) mental states and properties of the sort that were presumed in Rationalist accounts that Chomsky seemed to want to revive (but see John Collins and Rey's contribution in Chapter 31 for complexities here). They were particularly dismissive of the explanatory utility of talk of so-called "propositional attitudes," or talk that typically involves mental verbs, such as "believes," "prefers" that take a "proposition" or "that … " or "to … " clause as a direct object; thus, one believes *that it is raining* and prefers *to not get wet* – i.e., *that one not get wet,* which is ordinarily supposed to explain someone's avoiding the rain.

All such talk involves a curious property that Franz Brentano (1874/1995) had called "intentionality," or the "directedness" or "aboutness" of such attitudes on things real and often unreal, such as beliefs about Zeus and ghosts. Particularly for Chomskyans and other cognitive scientists, it would appear that the almost-ubiquitous term *representation* is intentional in this way: representations are always "of" something, which can be real or nonexistent as in the case of illusory triangles and unuttered words and sentences. But what determines what a representation is "of"?

What has been particularly worrisome about this and other issues regarding intentionality is that Brentano plausibly argued that it was not "reducible" to a physical phenomenon (after all, how can a physical phenomenon involve a relation to something that doesn't exist?), and many have tried, but no one has yet quite succeeded in proving him wrong. In an influential discussion, Quine (1960/2013:221) claimed these failures revealed "the baselessness of the intentional idiom and the emptiness of a science of intention."

Now, one might have thought that Chomsky's resuscitation of innate ideas and appeals to "mental" processes had given the lie to Quine's view. However, beginning in the 1990s, Chomsky himself began to defend similar claims: "We can be reasonably confident that 'mentalistic talk' will find no place in attempts to describe and explain the world" (Chomsky 1996, 74-7). Indeed:

> [I]ntentional phenomena relate to people and what they do as viewed from the standpoint of human interests and unreflective thought, and thus will not (so viewed) fall within naturalistic theory, which seeks to set such factors aside. (Chomsky 2000, 22–23; see also p. 132)

But this seems incompatible with the many apparently intentionalistic appeals to the "representation" and "knowledge" of grammar that seem ubiquitous in Chomsky's other writings (and, indeed, in most cognitive science generally). How is Chomsky in this regard different from Quine? In their entry, Collins and Rey try to sort this issue out.

The problem of intentionality is only one of many mind–body problems that philosophers have traditionally addressed. Others are, of course, that of the peculiar "privacy" of subjective experience of "qualitative" phenomena (or *qualia*), such as the smell of roses or the feeling of pain, which it's hard to imagine an account of merely our bodies satisfactorily explaining. Chomsky has been surprisingly dismissive of these problems as well, claiming that, since Newton's theory of gravitation refuted Cartesian mechanics, we have no coherent notion of "body" with which we can even state such problems.[11] In Chapter 32, Joseph Levine discusses what he thinks is really driving contemporary

discussions of mind and body, arguing that they can be and often are pursued quite independently of Descartes' and any specific notion of body.

1.8 Part VIII: Methodological and Other Explanatory Issues

Part and parcel of Chomsky's rejection of the Positivism and empiricism that at least ideologically dominated much of philosophy and science up until about 1960 is his insistence on what he calls "the Galilean method," which he argues is responsible for the success of our most serious sciences, such as chemistry, biology, and physics. There are several issues often included under this term: for example, an insistence on mathematical formulations; a belief in the ultimate "simplicity" of nature; and the central role of idealization in successful explanations. To keep the topic manageable, we (the editors) have prepared Chapter 33 that focuses on the last topic, idealization, alone, since that is what seems to us to be most important to Chomsky's work (the other topics are less essential and far more controversial; see Boeckx 2006 for discussion).

Crucial to Chomsky's work is the idealization he initially distinguished in terms of linguistic "competence," which he thought was the only theoretically tractable component of the far too many things responsible for linguistic "performance," or actual speech production. In order to avoid an excessively behavioral conception some associated with "competence," he eventually replaced this talk by an even more idealized conception of an "I(nternal, intentional)-language," or a specific computational system of grammar that is one of a panoply of systems (e.g., of reasoning and decision making) responsible for what people think of as "language." This is contrasted with what he calls "E(xternal, extensional)-languages," such as "English," "French," or "Mandarin," the complexities of which Chomsky thinks we need to abstract away from in characterizing the underlying system. Chomsky reasonably claims that this sort of idealization is precisely what Galileo and Newton engaged in when they provided laws not of the complex motion of leaves in the wind, or clouds in a storm, but of objects falling in a vacuum, or of one point mass orbiting around another in empty space. We defend Chomsky's conception against the charges that it is nonempirical, leading to "unfalsifiable" theories, and ignores too many actual linguistic phenomena.

In fact, idealizations have been pursued in different ways by different proponents of a Chomskyan approach. As we have just noted, Chomsky himself has argued that systematic investigation of our linguistic abilities requires abstracting away from the interaction of the numerous systems presumably involved in performance, in order to narrow the focus to the competence embodied in the I-language. He also assumes that there are other faculties or mental "organs," and therefore recommends the same general methodology in investigating other aspects of cognition, such as the infant's ideas of objects in space and time, our number sense, and moral "grammar" (see references in section 6 above). In Chapter 34, Nicholas Allott and Neil Smith set out Chomsky's conception of such "competence" or "analytic" modules (as they have also been called) and their relation to processing, discussing three ways that it has been understood. But they also explore Jerry Fodor's *different* idealization, which he introduced with his influential notion of encapsulated "modules." This was inspired by Chomsky's notion of faculties, but, unlike them, Fodor's modules concern specific *processing* systems: in the case of language the system responsible for how speech is perceptually understood. Allott and Smith provide an overview of evidence for modularity from dissociation data, where

selective impairment of one ability leaves another ability intact, concluding that there is evidence both for Fodorian modularity of input systems, and for a central Chomskyan language faculty.

A related concern about Chomskyan linguistics has to do with its heavy reliance on speakers' "intuitions," or verdicts about the acceptability and interpretation of sentences or phrases presented to them in books or lectures, as in queries about WhyNots. These don't seem like the experimentally controlled data with which serious science is normally concerned. Indeed, such intuitions can seem more like the armchair speculations of traditional philosophers that have been the object of much recent skepticism. In Chapter 35, Steven Gross reviews much of the recent discussion of this topic, discussing the similarities and differences between such linguistic judgments and the kinds of judgments about visual appearances on which vision theorists routinely rely.

Chomsky's interest in idealization leads him to be skeptical about theories of insufficiently idealized domains, not only of "E-languages" and speech production, but of human behavior in general. To a first approximation, issues that might be amenable to an idealized explanation in terms of an underlying competence system he regards as problems while issues that involve massive interaction effects between systems such as the decision-making of agents, he regards as "mysteries," unamenable to scientific understanding. Collins calls attention in Chapter 36 to problems with the distinction as Chomsky draws it.

Many have wondered how someone so concerned with abstract idealizations of the sort Chomsky seeks in linguistics could also be as deeply concerned with such concrete and enormously complex phenomena as the kind of human behavior involved in politics. Part of Chomsky's view here is that political research is precisely *not* particularly theoretical, but involves simply paying closer attention to the mass of information about actual events of states and individuals in the world that, he argues, standard discussions in the public media often systematically ignore (Chomsky refers to the failure of people to learn the facts about present political realities as "Orwell's Problem." Whereas "Plato's Problem" is how people can learn so much given the exiguousness of experience, Orwell's is: how can people know so little, given the actual accessibility of political information). Joshua Cohen and Joel Rogers examined this issue at length in their (1991) article from which Chapter 37 has been excerpted, and they bring to light some of the background assumptions of Rationalism and the Enlightenment generally that have informed both Chomsky's linguistics and his political discussions.

Endnotes

1 See, for example, Cowie (1999), Pullum & Scholz (2002), Everett (2012), Evans and Levinson (2009), Tomasello (2003), Evans (2014), Chater, Clark, Goldsmith & Perfors (2015), and Christiansen & Chater (2017).

2 The focus on hierarchical structure and the generative ability of the grammar was a radical break with the work of Chomsky's mentor, Zellig Harris (see the biographical sketch), and all the other linguists of the era. Harris's work in the 1950s also made use of transformations, but these were different formally and in the (descriptive, not explanatory) role that they were intended to play. (See Collins 2008, 66–67; Newmeyer 1986, 4–6).

3 Declaratives are sentences of the type whose default use is making statements; interrogatives are of the type dedicated to asking questions. A polar (or *yes/no*) interrogative is one inviting a "yes/no" response (in contrast to *wh*-interrogatives which are formed with *wh*-words such as *who, what, where, which* – see below for examples of these).

4 For expository purposes, we illustrate the point using somewhat different examples from Chomsky 1955 and 1957 (cf. Chomsky 2013b, 651–652), and the theory as we set it out here (very informally) is closer to work from the 1960s. For a more rigorous presentation of the analyses in Chomsky 1957, including evidence for structure dependence, see Lasnik et al. 2000, especially chapter 1.

5 On this cognitive turn, see Collins (2008, ch. 4) and Chomsky (1975), where Chomsky says that questions of cognition were in the "immediate background" in his work in the 1950s, but he thought it "too audacious" to set them out. (See also below.) The *locus classicus* for the cognitive conception is Chomsky's influential *Aspects of the Theory of Syntax* (1965).

6 It's important to see that the universals of UG need not be manifested in every language. UG apparently provides options and constraints. Not every language makes use of every option, and thus some of the constraints may not be visible in that language. For example, the constraint barring *wh*-movement out of conjoined constituents (as in the example that follows) would not be visible in a language that lacks *wh*-words or conjunction.

7 Stars in front of a sentence indicate ungrammaticality. Some other WhyNots that point to other, more difficult-to-specify constraints:
   a. *Who did stories of scare Mary?
   b. *Who did Susan ask why Sam was waiting for __?
      (cf. *Susan asked why Sam was waiting for Bill*.)
   c. *Who do you wanna laugh? (cf. *I want Bill to laugh*.)
   d. *I want a book you've in the car (vs. *you have*).
   e. *I know I should go home, but I don't want *(to) (i.e., one needs "*to*").
   f. *He hopes John will win (where *he* = *John*).

8 Chomsky's master's thesis was an expanded version of his 1949 undergraduate honors essay, "Morphophonemics of modern Hebrew." (On this early work, see Newmeyer 1996, ch. 2.)

9 It is crucial to note that the issue here concerns the *characterization* of the grammar, with no commitment to whether or not "derivational steps" are realized in the brain in real time.

10 On the complex history of lexical semantics, with brief commentary on Chomsky's influence, see Pustejovsky 2016.

11 One mind/body problem that Chomsky does take seriously is the traditional problem of "free will," which many have thought is incompatible with the kind of "deterministic" theories that the natural sciences pursue. However, he (2010) regards this issue as not really a "problem" that can be addressed scientifically, but a "mystery" that will likely remain beyond possible human understanding. This view is sometimes associated with his views about the impossibility of a theory of speech "performance," but it is importantly independent of it: performance may simply be a massive interaction effect, unamenable to theory, involving no mysterious "free will" at all. Cf. below and Collins Chapter 36 of this volume.

References

Allott, N., and G. Rey. 2017. The many errors of Vyvyan Evans' *The Language Myth*. *The Linguistic Review* 34 (3): 1–20.

Apperly, I. 2010. *Mindreaders: The Cognitive Basis of "Theory of Mind."* Hove, *East Sussex: Psychology Press*.

Boeckx, C. 2006. *Linguistic Minimalism: Origins, Concepts, Methods, and Aims*. Oxford: Oxford University Press.

Brentano, F. 1874/*1995*. *Psychology from an Empirical Standpoint*. 2nd ed. London: Routledge.

Carey, S. 2009. *Origin of Concepts*. Oxford: Oxford University Press.

Chater, N., A. Clark, J. A. Goldsmith, and A. Perfors. 2015. *Empiricism and Language Learnability*. Oxford: Oxford University Press.

Chomsky, N. 1951. The Morphophonemics of Modern Hebrew. *Master's thesis*, University of Pennsylvania. (Published by Garland, New York, 1979.)

Chomsky, N. 1955. The Logical Structure of Linguistic Theory. Ms. Harvard University and MIT. Revised version published in part by Plenum, New York, 1975.

Chomsky, N. 1957. *Syntactic Structures*. The Hague: Mouton.

Chomsky, N. 1959. "Review of B. F. Skinner, 'Verbal behavior.'" *Language* 35: 26–58.

Chomsky, N. 1962. "Explanatory models in linguistics." In *Logic, Methodology, and the Philosophy of Science*, edited by E. Nagel, P. Suppes, and A. Tarski, 528–50. Stanford: Stanford University Press.

Chomsky, N. 1965. *Aspects of the Theory of Syntax*. Cambridge: MIT Press.

Chomsky, N. 1966. *Cartesian Linguistics*. New York: Harper and Row.

Chomsky, N. 1968/2006. *Language and Mind*. 3rd ed. Cambridge: Cambridge University Press.

Chomsky, N. 1975. *Introduction to The Logical Structure of Linguistic Theory*. New York: Plenum Press.

Chomsky, N. 1995a. Language and nature. *Mind* 104 (413): 1–61.

Chomsky, N. 1995b. *The Minimalist Program*. Cambridge: MIT Press.

Chomsky, N. 1996. *Powers and Prospects*. Boston: South End Press.

Chomsky, N. 2000. *New Horizons in the Study of Language and Mind*. Cambridge: Cambridge University Press.

Chomsky, N. 2010. The mysteries of nature: How deeply hidden? In *Chomsky Notebook*, edited by J. Bricmont, and J. Franck, 3–33. New York: Columbia University Press.

Chomsky, N. 2013a. Problems of projection. *Lingua* 130 33–49.

Chomsky, N. 2013b. What kind of creatures are we? Lecture I: What is language? *The Journal Of Philosophy CX* (12): 645–62.

Chomsky, N. 2015. Some core contested concepts. *Journal of Psycholinguistic Research* 44 (1): 91–104.

Chomsky, N., and M. Halle. 1968. *The Sound Pattern of English*. Cambridge: MIT Press.

Chomsky, N., and M-P. Schützenberger. 1963. "The algebraic theory of context-free languages." In *Computer Programming and Formal Systems*, edited by B. Braffort and D. Hirschberg, 118–161. Amsterdam: North Holland.

Christiansen, M., and N. Chater. 2017. "Towards an integrated science of language." *Nature Human Behavior* 1 (8): 0163.

Cohen, J., and J. Rogers. 1991. "Knowledge, morality and hope: The social thought of Noam Chomsky." *New Left Review* 187: 5–27.

Collins, J. 2008. *Chomsky : A Guide for the Perplexed*. London: Continuum.

Cowie, F. 1999. *What's Within: Nativism Re-Considered*. Oxford: Oxford University Press.

Evans, N., and S. C. Levinson. 2009. "The myth of language universals: language diversity and its importance for cognitive science." *Behavioral and Brain Sciences* 32 (5): 429–448.

Evans, V. 2014. *The Language Myth*. Cambridge: Cambridge University Press.

Everett, D. 2012. *Language: The Cultural Tool*. New York: Pantheon Books.

Harris, Z. 1951. *Methods in Structural Linguistics*. Chicago: University of Chicago Press.

Lasnik, H., with Depiante, M. A. and A. Stepanov. 2000. *Syntactic Structures Revisited : Contemporary Lectures on Classic Transformational Theory*. Cambridge: MIT Press.

Lasnik, H., and T. Lohndal. 2013. "Brief overview of the history of generative grammar." In *The*

Cambridge Handbook of Generative Syntax, edited by M. den Dikken, 26–60. Cambridge: Cambridge University Press.

Mikhail, J. 2011. *Elements of Moral Cognition: Rawls' Linguistic Analogy and the Cognitive Science of Moral and Legal Judgment*. Cambridge: Cambridge University Press.

Miller, G. A. 2003. "The cognitive revolution: a historical perspective." *TRENDS in Cognitive Sciences* 7 (3): 141–144.

Newmeyer, F. J. 1986. Has there been a 'Chomskyan revolution' in linguistics? *Language* 62 (1): 1–18.

Newmeyer, F. J. 1996. *Generative Linguistics: A Historical Perspective*. London: Routledge.

Pullum, G., and B. Scholz. 2002. Empirical assessment of stimulus poverty arguments. *The Linguistic Review* 19: 9–50.

Pustejovsky, J. 2016. Lexical semantics. In *The Cambridge Handbook of Formal Semantics*, edited by M. Aloni and P. J. E. Dekker, 33–64. Cambridge: Cambridge University Press.

Quine, W. 1960/*2013. Word and Object*. 2nd ed. Cambridge: MIT Press.

Sells, P. 1985. *Lectures on Contemporary Syntactic Theories: An Introduction to Government-Binding Theory, Generalized Phrase Structure Grammar, and Lexical-Functional Grammar*. Stanford: CSLI.

Skinner, B. F. 1957. *Verbal Behavior*. Acton, MA: Copley Publishing Group.

Spelke, E. 2003. Developing knowledge of space: Core systems and new combinations. In *Languages of the Brain, edited by S*. M. Kosslyn and A. Galaburda (eds.), 239–258. Cambridge, MA: Harvard University Press.

Tomasello, M. 2003. *Constructing a Language: A Usage-Based Theory of Language Acquisition*. Cambridge, MA: Harvard University Press.

2

Biographical Sketch

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As the synoptic introduction (Chapter 1) makes clear, Noam Chomsky is a unique intellectual figure who has had a huge impact on several fields. He was almost single-handedly responsible for initiating the cognitive revolution in linguistics, and, with others such as George Miller, Hilary Putnam and Jerry Fodor, for the ensuing replacement of behaviorism by cognitive science in psychology generally, to say nothing of being a leading critic of American foreign policy since the American war in Vietnam.

Chomsky has always been a rather private person, writing, "I'm really a hermit by nature, and would much prefer to be alone working than to be in public" (quoted in Falk 1994, 597, n.1). Nevertheless, aspects of his personal life and education, especially up to his appointment to MIT in his mid-twenties, are illuminating of the origins of his future work and political engagement.

Here we try to summarize some of the main biographical facts about Chomsky's life. It is impossible to do full justice to the milieux that have influenced Chomsky and that he has shaped in such in a short sketch. Interested readers should consult Barsky (1998, 2011) and Chomsky (1987, 2009) for much more detail.

Avram Noam Chomsky was born on December 7, 1928, in Philadelphia, Pennsylvania. His parents were born in the Russian empire (in what are now Ukraine and Belarus), but met in the United States. His father, William Chomsky, was a scholar and teacher of Hebrew and wrote a seminal book on the history of the Hebrew language. His mother, Elsie Chomsky (née Simonofsky), was also a Hebraist and educator. They taught and had leadership roles at Gratz College, which was both a teacher training college and a center for academic study of Judaism. (For discussion of the significant influence Chomsky's parents had on his thinking, see Barsky 1998, 9–14.)

Chomsky lived in Philadelphia until he moved to Boston in 1951. From the age of about 2 to 11, he attended a progressive Deweyite school run by Temple University, a school that emphasized creativity and encouraged students to pursue their own interests. He was already becoming intensely interested in politics. He describes himself as "a child of the Depression" with vivid early memories "of people selling rags at my door,

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of violent police strikebreaking, and other Depression scenes" (Chomsky 1987). He was also affected by international events, particularly the Spanish civil war. At the age of 10, he wrote his first article, an editorial for his school newspaper on the fall of Republican Barcelona to Franco's forces.

Chomsky then went on to attend the Central High School in Philadelphia, a mainstream academically oriented school that he found competitive and unpleasant: "I remember virtually nothing about high school […] apart from the emotional tone, which was quite negative" (Chomsky 1987; see also Chomsky 2009; Peck 1987, 5–6). Chomsky recalls that at this time, he was influenced by members of his extended family and their political environment, more working class and left wing than his parents. From the age of 13, he would travel on his own to New York, where an uncle ran a newsstand, "which was sort of a radical center. We'd hang out all night and have discussions and arguments" (Chomsky 1987; see also McGilvray 2009).

In 1945, at the age of 16, Chomsky enrolled at the University of Pennsylvania, paying for his education by teaching Hebrew in the evenings and on Sundays. At the beginning he found the structure stifling and the classes largely uninteresting: the exceptions were courses on Arabic and a freshman course in philosophy. He was planning to drop out after two years to pursue his political interests (Chomsky 1987; Barsky 1998, 47).

However, in 1947 those political interests led to Chomsky getting to know Zellig Harris: they were both radical left-wing Zionists. But Harris was also one of the most important linguistic structuralists in the United States, and he was working on what became his most influential contribution: *Methods in Structural Linguistics*, completed in 1947 (but published as Harris 1951). Harris gave Chomsky the proofs to read and Chomsky decided to go on with linguistics. On Harris's recommendation, Chomsky took seminars with the philosopher Nelson Goodman, with whom he became close friends, as well as courses with the philosophers Morton White, Richard Martin, and Henry Hiż, and the mathematician Nathan Fine (Chomsky 1987; Hughes 2001; Meguire 2005). Chomsky received his BA from the University of Pennsylvania in 1949, having written an undergraduate thesis on the morphophonemics of Hebrew, which already included key elements of what was to become generative grammar. (He extended and revised this as his master's thesis in 1951.)

Also in 1949, Chomsky married Carol Schatz, a fellow student at the University of Pennsylvania. They came from the same community in Philadelphia – her mother worked at the Hebrew school where William Chomsky was the principal – and they had first met as young children (Marquard 2008). They had three children, Aviva (born 1957), Diane (1960), and Harry (1967), and were married until her death in 2008. In the 1960s, when Chomsky was involved in political demonstrations and resistance activities and at risk of being jailed, Carol Chomsky went back to university to get a doctorate, anticipating that she would need to be the breadwinner for the family (Marquand 2008). She made important contributions to the understanding of language acquisition in children (e.g. C. Chomsky 1969), working from 1972 at the Harvard Graduate School of Education.

The Chomskys moved to Boston in 1951, Noam having become, on Goodman's advice and recommendation, a Junior Fellow of the Harvard Society of Fellows: "the first time I could devote myself to study and research without working on the side" (Chomsky 1987). During the four years at Harvard (with a period abroad on a socialist kibbutz in Israel for about six weeks in 1953), he got to know graduate students Morris Halle and Eric Lenneberg, as well as the noted linguist Roman Jakobsen and the

philosophers W.V.O. Quine and J.L. Austin (who visited Harvard in 1955). Chomsky pursued his own approach to linguistics, appealing to abstract structure in accounting for linguistic patterns: a massive break with Zellig Harris's theory.

Chomsky was awarded his PhD from the University of Pennsylvania in 1955, based on only one chapter of his thesis, a roughly 500-page manuscript that came to be widely circulated in mimeograph, *The Logical Structure of Linguistic Theory* (finally published in slightly revised form in 1975). The manuscript was highly influential, in particular for the more technical and formal aspects of the new approach to language that Chomsky was developing.

In 1955, on the recommendation of Jakobsen, Chomsky joined MIT as an assistant professor (Barsky 1998, 86). He was in theory supposed to work on a machine translation project in the MIT Research Laboratory of Electronics, but that never happened. Instead, he worked on what became *Syntactic Structures*, and taught undergraduate philosophy courses, among others. In 1961, he was promoted to full professor of Foreign Languages and Linguistics, and then appointed Ferrari Ward Professor of Linguistics in 1966. In 1976, he was appointed Institute Professor, the highest honor MIT bestows on a faculty member. After his official retirement in 2002, he continued to work and serve the MIT community until the fall of 2017.

In the late 1950s, Chomsky's work had begun to receive some recognition; he was invited to major conferences, and people started to become familiar with some of his revolutionary ideas. His name became significantly more visible as a result of his 1959 review of B. F. Skinner (see the synoptic introduction). With his attack on behaviorism, he became one of the preeminent figures in what later became known as the "cognitive revolution," and his fame within the field of linguistics continued to grow.

From the early 1960s, Chomsky became increasingly engaged in political activities (Hughes 2001). A significant turning point came in February 1967 with the publication of "The Responsibility of Intellectuals" in the *New York Review of Books*. With this essay, he emerged as a leading critic of the war in Vietnam (for appraisal of its significance, see Allott 2019; Parini 2017), and since then, he has been a highly visible public intellectual, known in particular for his critique of American foreign policy and his work with Edward Herman on the role of the mass media in democracies in "manufacturing consent."[1]

Since the 1960s, Chomsky has published prodigiously on both linguistics and politics. His work in syntax has revolutionalized the field several times, but it has always explored the implications of studying grammar in the way that he set out in the 1950s and early 1960s, as a generative mental system, largely innately specified. For several decades he traveled the world nearly continuously and he has given countless public and specialized talks to all sorts of audiences.

Chomsky has been awarded more than 40 honorary degrees. In 1988, he received the Kyoto Prize for Basic Sciences, created in 1984 to recognize work in areas not included among the Nobel Prizes. Other awards include the Benjamin Franklin Medal, the Leonard Euler Medal, the Erich Fromm Prize, the British Academy's Neil and Saras Smith Medal for linguistics and the Collar of the Order of Timor-Leste. He is also a fellow of the American Academy of Arts and Sciences, the National Academy of Science, the British Academy, the American Philosophical Society, the American Psychological Society, and the Linguistic Society of America.

In 2014, Chomsky married Luisa Valéria Galvão-Wasserman, a translator for the Institute of Advanced Studies (IEA) of the University of São Paulo, Brazil. Since the fall

of 2017, they have lived in Tucson, Arizona, where Chomsky was appointed a laureate professor in linguistics at the University of Arizona and also holds the title of Agnese Helms Haury Chair in the Agnese Helms Haury Program in Environmental and Social Justice. In his 93rd year, he still teaches courses on linguistics and on issues relating to his political activist work.

Endnote

1 On the motivation for Chomsky's political work, John Horgan writes: "I once asked Chomsky which work he found more satisfying, his political activism or his linguistic research. He seemed surprised that I needed to ask. Obviously, he replied, he spoke out against injustice merely out of a sense of duty; he took no intellectual pleasure from it. If the world's problems suddenly disappeared, he would happily, joyfully, devote himself to the pursuit of knowledge for its own sake" (Horgan 2016).

References

Allott, N. 2019. Introduction: "The responsibility of intellectuals": What it does and does not say. In *The Responsibility of Intellectuals: Reflections By Noam Chomsky and Others After 50 Years*, edited by N. Allott, C. Knight, and N. V. Smith, 1–4. London: UCL Press.

Barsky, R. F. 1998. *Noam Chomsky: A Life of Dissent*. Cambridge: MIT Press.

Barsky, R. F. 2011. *Zellig Harris: From American Linguistics to Socialist Zionism*. Cambridge: MIT Press.

Chomsky, C. 1969. *The Acquisition of Syntax in Children from 5 to 10*. Cambridge: MIT Press.

Chomsky, N. 1967. The responsibility of intellectuals. *The New York Review of Books February* 23, 1967. Available at https://chomsky.info/19670223/

Chomsky, N. 1987. Personal influences [excerpted from The Chomsky Reader]. Available at https://chomsky.info/reader01/

Chomsky, N. 2009. Infinite History Project [video interview with Karen Arenson]. Available at https://archive.org/details/NoamChomsky-InfiniteHistoryProject-2009/

Falk, R. 1994. Letters from prison – American style: The political vision and practice of Noam Chomsky. In *Noam Chomsky: Critical Assessments*, edited by C. P. Otero, 578–597. London: Routledge.

Harris, Z. 1951. *Methods in Structural Linguistics*. Chicago: The University of Chicago Press.

Herman, E. S., and N. Chomsky. 1988. *Manufacturing Consent: The Political Economy of the Mass Media*. New York: Pantheon Books.

Horgan, J. 2016. Noam Chomsky is so anti-establishment he disses himself. *Scientific American blog, November* 29, 2016. Available at https://blogs.scientificamerican.com/cross-check/noam-chomsky-is-so-anti-establishment-he-disses-himself/

Hughes, S. 2001. Speech! *The Pennsylvania Gazette*, July/Aug 2001. Accessed at https://www.upenn.edu/gazette/0701/hughes.html

Marquard, B. 2008. Carol Chomsky; at 78; Harvard language professor was wife of MIT linguist. *The Boston Globe*, December 20, 2008. Accessed at http://archive.boston.com/news/education/higher/articles/2008/12/20/carol_chomsky_at_78_harvard_language_professor_was_wife_of_mit_linguist/

Meguire, P. 2005. Richard Milton Martin: American logician. *The Review of Modern Logic,* 10 (1-2): 7–66.

McGilvray, J. 2009. Noam Chomsky: American linguist. In *Encyclopedia Britannica*. Available at https://www.britannica.com/biography/Noam-Chomsky.

Parini, J. 2017. Noam Chomsky's "Responsibility of intellectuals" after 50 years: It's an even heavier responsibility now. *Salon*, February 11, 2017. Available at https://www.salon.com/2017/02/11/noam-chomskys-responsibility-of-intellectuals-after-50-years-its-an-even-heavier-responsibility-now/

Peck, J. (ed.) 1987. *The Chomsky Reader*. New York: Pantheon.

Part I

Historical Development of Linguistics

3

From the Origins of Government and Binding to the Current State of Minimalism[1]

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3.1 Setting the Scene

Generative grammar is an approach to the study of language which is explicit, mentalistic, and based on the claim that the ability to acquire language is innately specified.[2] The approach is concerned with language as a psychologically real object, whose representations can be studied scientifically. In the words of Chomsky (1975, p. 160): "Linguistics is simply that part of psychology that is concerned with one specific class of steady states, the cognitive structures that are employed in speaking and understanding." Put differently, "[w]e have grammars in our heads" (Smith and Allott 2016, p. 128). We humans come prewired with the ability to create these grammars: We are born with a unique ability to acquire language.

Throughout its history, three questions have been at the center of this approach. They are given in (1).[3]

(1) a. What constitutes knowledge of language?
b. How is knowledge of language acquired?
c. How is knowledge of language put to use? (Chomsky 1986)

The first question seeks to establish the basis for our linguistic ability. Linguists often speak of this in terms of *knowledge,* but this is not the kind of knowledge that many philosophers will have in mind. Chomsky (1982, p. 128) says the following:

> As I am using the term, knowledge may be unconscious and not accessible to consciousness. It may be "implicit" or "tacit." No amount of introspection could tell us what we know, or cognize, or use certain rules or principles of grammar, or that use of language involves mental representations formed by these rules and principles. We have no privileged access to such rules and representations.[4]

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Furthermore, generative scholars are interested in how children are able to acquire these representations for each variety or language. Lastly, an important question is how we humans utilize these representations in language use.

Since its inception, generative grammar has made at least three fundamental contributions to our understanding of language: (i) viewing grammars as formal/mathematical objects, (ii) viewing linguistics as psychology and biology: studying the emergence and structure of the mental architecture underlying language, (iii) Universal Grammar, the proposal that there is innate, mental structure which is specific to language and that enables children to acquire any language. These results have partly come about through the focus on descriptive adequacy, descriptions of the intrinsic competence of a speaker, and on explanatory adequacy, how a child acquires this intrinsic competence:[5]

> To the extent that a linguistic theory succeeds in selecting a descriptively adequate grammar on the basis of primary linguistic data, we can say that it meets the condition of *explanatory adequacy*. That is, to the extent, it offers an explanation for the intuition of the native speaker on the basis of an empirical hypothesis concerning the innate predisposition of the child to develop a certain kind of theory to deal with the evidence presented to him." (Chomsky 1965, pp. 25–26; his italics)

This enabled the study of grammars that humans have internalized, unlike, say, studying a finite corpus.

In this chapter, we will outline some of the recent history leading up to contemporary generative grammar. We will first provide some context for the emergence of Principles and Parameters, before we provide the basic gist of the Principles and Parameters approach. Then we introduce the first model that was proposed, namely Government and Binding. This is followed by a discussion of the second and to this date current model, the *Minimalist Program*, before we try to outline some of the current trends that shape the field of generative grammar. Lastly, we summarize and conclude the chapter.

3.2 Some Context: The Emerging Idea of Principles and Parameters

A core aspect of generative grammar in its early days was a computational system in the human mind that contained phrase structure rules for building hierarchical structures and more complex operations that were able to modify these phrase structures. The latter were known as transformations, and transformations crucially operated on structures, not, say, sentences as in Harris (1951). This gave rise to the name *Transformational Grammar,* which is synonymous with generative grammar. Transformations made the theory much more powerful as it allowed an infinite number of grammars (cf. Lasnik 2000, p. 114; Lasnik and Lohndal 2013, pp. 27–28), raising serious questions regarding learnability: How can a child select the correct target grammar from all available grammars? In this section, we will summarize some of the most important context leading up to the Principles and Parameters approach, which we will present in section 3. For reasons of space, the present section will have to set aside a lot of details, but see Freidin and Lasnik (2011) and Lasnik and Lohndal (2013) for a more detailed exposition.

The grammatical architecture proposed in Chomsky (1965) looks as in (2) (Chomsky 1965, pp. 135–136, cf. also Lasnik and Lohndal 2013, p. 36).

(2)

Deep Structure	⇒	Semantic Interpretation
⇓		
Transformations (operating cyclically)		
⇓		
Surface Structure ⇒		Phonetic Interpretation (via the "sound-related" levels of Morphophonemics, phonemics, and phonetics)

To give one example, we can consider simple questions. In Chomsky (1955, 1957), (3a) and (3b) had the same initial phrase structure (called *phrase marker* at the time).

(3) a. Ellie will solve the problem.
b. Will Ellie solve the problem?

Transformations take the structure of (3a) and transforms it into the structure of (3b). The details are not important; readers can consult Lasnik (2000) for a lucid exposition. A remarkable success of this approach, as Lasnik (2005, 69) emphasizes, is that it enabled a unified analysis of (3) and (4).

(4) a. Ellie solved the problem.
b. Did Ellie solve the problem?

Native speakers can sense a relationship between (3b) and (4b), but prior to Chomsky's analysis, there was no account of this. In Chomsky (1965), the technicalities were different, but the intuitions were the same: A common underlying Deep Structure as the basis for both declaratives and interrogatives, and then transformations that altered the structure into a surface structure, followed by morphophonological operations that provide the accurate forms for phonetic interpretation.

Transformations are an essential and powerful part of this architecture. Because of this, work conducted in the late 1960s and 1970s suggested a range of constraints to limit the power of transformations and consequently the range of possible grammars. An example of this is the work by Ross (1967), which proposed constraints on long-distance dependencies (Ross labeled them *islands*; see Boeckx 2013, den Dikken and Lahne 2013 and Müller, Chapter 12 of this volume for overviews). Nevertheless, as Chomsky and Lasnik (1977) point out, the quest for descriptive adequacy led to a tremendously rich theory. This can be seen quite clearly in Peters and Ritchie (1973), whose explicit formalization contains a range of mechanisms that were proposed at the time, such as global rules and transderivational constraints. Let us look at these mechanisms briefly (building on the discussion in Lasnik and Lohndal 2013).

Lakoff (1970, p. 628) defines a global rule as a rule that states conditions on "configurations of corresponding nodes in nonadjacent trees in a derivation." In general, transformations have always been assumed to be Markovian, that is, that they involve one step at the time. However, global rules require a system that dramatically extends the power beyond Markovian properties. Ross (1969) famously provided an example of a global rule. In this paper, he extends results he obtained in Ross (1967) involving island constraints. One such island constraint is illustrated in (5), the Coordinate

Structure Constraint, which prevents extraction from just one of the conjunctions. We have illustrated that by showing in (5) a copy of *who* in the position from which it has been deleted.

(5) *Irv and someone were dancing, but I don't know who Irv and ~~who~~ were dancing.

Notably, Ross (1969) showed that if the constraint isn't visible, it goes away. A way to make it disappear is to use ellipsis, as in (6).

(6) Irv and someone were dancing, but I don't know who.

In (6), the coordinate structure, the constituent that forms the island, has been elided and is not pronounced. That makes the example acceptable. More formally, Ross argued that for an island violation to occur, the constituent that forms the island needs to be present at surface structure. If a transformation deletes this constituent, the constraint no longer applies. This deletion became known as *sluicing* (see van Craenenbroeck and Merchant 2013). To capture the contrast between (5) and (6), island constraints need to mention both the surface structure and the point in the derivation where the movement of the relevant constitutent (*who* in (5)) takes place, the coordinate structure in (5). That the constraint needs to mention both properties makes it a global rule.

As for transderivational constraints, such constraints depend on derivations different from the one that is being considered. Hankamer (1973) provides arguments in favor of such constraints. One example involves the phenomenon known as *gapping* (see van Craenenroeck and Merchant 2013). Among others, he uses the example in (7) (Hankamer 1973, pp. 26–27).

(7) Max wanted Ted to persuade Alex to get lost, and Walt, Ira.

The question is how such a string is derived, that is, what is the correct derivation underlying (7)? Possible candidates could be (8a) or (8b).

(8) a. Max wanted Ted to persuade Alex to get lost,
*and Walt [wanted] Ira [to persuade Alex to get lost]
b. Max wanted Ted to persuade Alex to get lost,
*and Walt [wanted Ted to persuade] Ira [to get lost]

Hankamer argued that both options in (8) are out because (7) can also be derived from a different constituent structure which still derives the intended meaning, namely (9).

(9) Max wanted Ted to persuade Alex to get lost,
and [Max wanted] Walt [to persuade] Ira [to get lost]

When the bracketed constituents are deleted, (9) becomes (7). Given this, the constraint would not just have to make reference to alternative derivations created from the same deep structure, but also to alternative derivations created from *different* deep structures. That raises nontrivial questions concerning the expressive power of such a computational system, and consequently also its learnability.[6]

Any extension of the class of possible grammars requires significant empirical justification. Chomsky and Lasnik (1977) argued that this justification had not been provided in approaches that extended the original framework in Chomsky (1955/1975, Peters and Ritchie (1973), and comparable work, cf. Dougherty (1973), Chomsky (1973), and Brame (1976). Because of that, Chomsky and Lasnik proposed a new framework which restricted the number of possible grammars significantly. This was seen as a crucial step towards being able to explain the acquisition of grammatical competence, a central goal ever since Chomsky (1965).

The new framework departed from earlier frameworks in some crucial ways, not at least in assuming that Universal Grammar is not an "undifferentiated" system. That is, it was argued that core grammar has highly restricted options, since it consists of universal principles and a few parameters that account for variation. In addition to the core, there is the periphery, consisting of "marked" phenomena, e.g. irregularities (i.e. irregular verbs) and exceptions more generally (e.g. English has prepositions, but also the marked exception *ago* – which comes *after* its complement). In other words, the approach required something similar to a theory of markedness, with all its complications (see Haspelmath 2006 for a comprehensive discussion). As Chomsky and Lasnik (1977, p. 430) say:

> Systems that fall within core grammar constitute "the unmarked case"; we may think of them as optimal in terms of the evaluation metric. An actual language is determined by fixing the parameters of core grammar and then adding rules or rule conditions, using much richer resources, perhaps resources as rich as those contemplated in the earlier theories of [transformational grammar][7]

Research was generally devoted to the core phenomena: "A reasonable approach would be to focus attention on the core system, putting aside phenomena that result from historical accident, dialect mixture, personal idiosyncrasies, and the like" (Chomsky and Lasnik 1993, p. 510).

The name for constraints in Chomsky and Lasnik (1977) was "filters." In their paper, the hypothesis was that surface filters can capture effects of ordering, obligatoriness and contextual dependencies. Such surface filters would be universal; thus, we would not expect any variation between languages. This makes filters different from parameters. Furthermore, a third component was language-specific filters. For example, to capture the ill-formedness of (10a) in Standard English, the language-specific filter in (10b) was proposed.

(10) a. *We want for to win.
b. *[for-to]

This filter deems any *for-to* string illicit. Chomsky and Lasnik (1977, p. 442) claim that the rule in (10b) would be a "dialect" filter, since it was assumed to involve "a high degree of uncertainty and variation." And, indeed, *for to* sequences are perfectly possible in for example Irish English dialects. In essence, then, a filter can either be outside of core grammar, like (10b), or part of core grammar, like the ban on stranding an affix (The Stranded Affix Filter, cf. Lasnik 1981).

Chomsky and Lasnik's (1977) paper prepared the ground for a major change in how to think about universality and variation. We turn to that in the next section.

3.3 Principles and Parameters: Solving Plato's Problem

Chomsky (1981) is a fundamental contribution to the study of human language in its effort to develop a new theory of what is universal across languages and what is variable. The main change affected the notion of filters, which came to be replaced by parameters. Parameters were seen as providing the solution to two issues: How can we capture the observed variation across the world's languages, and how do humans know so much given the limited evidence that is available to us (Plato's problem). The idea was that the child only had to set the correct value, which mostly was thought to involve a choice between two options, much like a switchbox as James Higginbotham put it. The head parameter is a simple example of this: You look at whether the verb precedes or follows the object, which gives you the two main word orders across the world's languages: verb–object, or object–verb. As Chomsky pointed out:

> If these parameters are embedded in a theory of UG that is sufficiently rich in structure, then the languages that are determined by fixing their values one way or another will appear to be quite diverse (Chomsky 1981, p. 4).

Importantly, on this approach, the space of linguistic variation is part of UG.

An essential part of the framework was clustering, that is, parameters should represent clusters of properties. Chomsky (1981, p. 6) put it as follows: "[I]deally we hope to find that complexes of properties […] are reducible to a single parameter, fixed in one or another way." A prominent example of this reasoning is provided by the Null Subject Parameter (Rizzi 1982; see also D'Alessandro 2015 for a review), which governs the realization of silent subjects, like in Spanish and many other languages. An example is provided in (11), where the subject does not have to be pronounced. This contrasts markedly with the same sentence in English, where the subject cannot be left out.

(11) (Voi) state leggendo un libro. (Italian)
you.PL are reading a book
"You are reading a book." (D'Alessandro 2015)

Rizzi (1982) argued that being a null subject language is correlated with several other properties: i) the subject can be moved out of a finite embedded clause that is headed by an overt complementizer, (12), ii) they allow for subject inversion (Kayne 1980), (13), iv) these are languages with so-called rich agreement on the verb (Taraldsen 1980; Alexiadou and Anangostopoulou 1998), in which both referential and nonreferential (so-called expletive) null subjects are licensed, unlike in non-null subject languages, (14).

(12) ¿Quién$_i$ dijiste que t_i salió temprano? (Spanish)
who say-PRET.2.SG THAT leave-PRET.3.SG early
'Who did you say that left early?" (Perlmutter 1971, p. 103)

(13) a. È arrivato Gianni. (Italian)
b. *Est arrivé Jean. (French)
c. *Has arrived John. (English) (Roberts 2007, p. 28)

(14) a. It rains frequently in April.
b. *Rains frequently in April.
c. *Ello/Lo llueve a menudo en abril. (Spanish)
it.STRONG/it.CLITIC rain.3SG frequently in April
d. Llueve a menudo en abril.
'It rains frequently in April.' (Judy and Rothman 2010, pp. 200–201)

This clustering highlights another virtue of the clustering idea, namely that properties that are hard to observe for the child are linked to properties that are easy to observe. It is easy for a child to determine whether the language in question is a null subject language or not, but it is not easy to observe the relevant data that will tell her that extraction out of a finite embedded clause with an overt complementizer is licit or not, as in (12). Such data are not very frequent, and this may create problems when it comes to extracting the right generalization from them when they are observed. If the clustering claim is true, the model really would have solved Plato's problem in abstraction: Learners do not have to compare whole grammars; they need to learn one parameter after the other. This would be a small number of choices, each of which would not involve many options. However, this only holds in abstraction because the model was never supplemented with an actual theory of how the child would learn the relevant parameter settings from the input.

We said "if true" because a lot of work since has cast a lot of doubt on the particular clustering that Rizzi (1982) argued for (e.g. Haspelmath 2008, Jaeggli and Hyams 1988, Newmeyer 2005, Rothman and Iverson 2007; Rothman 2009a, Sheehan, Chapter 11 of this volume). Baker (2008, p. 352) claims that "[h]istory has not been kind to the Pro-drop Parameter as originally stated." Since Chomsky (1981), the mainstream view on parameters has changed quite a bit, as Sheehan (Chapter 11) illustrates and which we will return to briefly below.

The first part of Principles and Parameters (P&P) was immensely productive, in particular from a cross-linguistic point of view. Hornstein (2013, p. 399) puts this well in the following quote:

> It is important to appreciate how fecund and productive this period of research [up to the 1990s] was. Arguably, we learned more new facts about more typologically diverse languages than ever in the history of the study of language. We learned a tremendous amount about how languages and grammars operate, what they have in common and how they differ.

This is an important result that is often underappreciated by Chomsky's critics.

The Principles and Parameters theory came to have two different instantiations or models (cf. Freidin and Vergnaud 2001, Hornstein, Nunes and Grohmann 2005, Lasnik and Uriagereka 2005, Boeckx and Uriagereka 2006, Lasnik and Lohndal 2010, 2010, Freidin 2012). The first one was called Government and Binding, and this was the model that was developed and used throughout the 1980s. In the beginning of the 1990s, Chomsky developed a new model, called the Minimalist Program. We will discuss the essentials of Government and Binding in the next section, and then in section 3.5, explain the transition to the Minimalist Program.

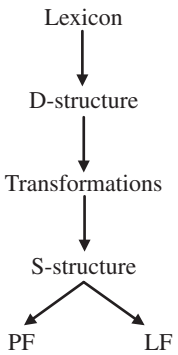
3.4 Government and Binding

The main idea behind the model of grammar labeled Government and Binding (GB) was developed by Chomsky in several publications (1981, 1982, 1986). According to Chomsky (1981, p. 5ff.), the theory of grammar consists of a rule system and its subcomponents, depicted in (15), and a system of principles and its subcomponents, shown in (16). The overall architecture is provided in (17).

(15) Rule system
1. lexicon
2. syntax
a. categorial component
b. transformational component
3. Phonetic Form
4. Logical Form

(16) Principle system
i. bounding theory
ii. theta-theory
iii. binding theory
iv. goverment theory
v. case theory
vi. control theory

(17) Y-model



In constructing a sentence (what is typically called the *derivation*), the grammar machine starts out with lexical and functional items from the lexicon. The lexicon contains all idiosyncratic information about lexical items. In turn, these items feed the syntax by way of assembling a D-structure where argument structure properties are assigned, i.e. a transitive verb will be in a configuration with an object and a subject, and an intransitive verb with just a subject. Then transformations (called Move α, where α stands for any constituent) map this structure into an S-structure (e.g. in the case of *wh*-movement as in *What did Jane read?*, which starts out with the structure *Jane read what*), which fairly closely resembles the surface order of words. At this point, the resulting structure is transferred to the two interpretive interfaces: Phonetic Form

(sound) and Logical Form (meaning). Note also that the principal subsystems in effect apply wellformedness constraints on the other levels of representation. Chomsky (1981, pp. 5–6) summarizes the organization of the grammar as follows:

> The lexicon specifies the abstract morpho-phonological structure of each lexical item and its syntactic features, including its categorial features and its contextual features. The rules of the categorial component meet some variety of X-bar theory. Systems 1.1 and 1.2a constitute the base. Base rules generate D-structures (deep structures) through insertion of lexical items into structures generated by 1.2a, in accordance with their feature structure. These are mapped to S-structure by the rule Move-alpha, leaving traces coindexed with their antecedents; this rule constitutes the transformational component 1.2b, and may also appear in the PF- and LF-components. Thus the syntax generates S-structures which are assigned PF- and LF-representations by components 3 and 4 of 1. Bounding theory poses locality conditions on certain processes and related items. The central notion of government theory is the relation between the head of a construction and categories dependent on it. Theta-Theory is concerned with the assignment of thematic roles such as agent-of-action, etc . . . . Binding theory is concerned with relations of anaphors, pronouns, names, and variables to possible antecedents. Case theory deals with assignment of abstract Case and its morphological realization. Control theory determines the potential for reference of the abstract pronominal element PRO.

Much more can be said about each of these components, and Haegeman (1994) provides an excellent and detailed exposition. Many other textbooks also exist, so in the interest of space, we will not provide a more detailed outline of the GB architecture. Some necessary details will be covered in the discussion of the Minimalist Program in the next section, but rather than go through the entire system here, we want to highlight a more general aspect of the model.

The above picture demonstrates the division of the language module into distinct submodules. In addition, it is assumed that the language faculty is a module of the mind distinct from other modules such as for instance the visual system. Chomsky's notion of modularity is very different from Fodorian modules (Chomsky 2018 compares his position to Fodor). For Fodor, human cognition consists of a "central system" and a number of "input systems" (Fodor 1983). The Fodorian modules are cognitive "reflexes" – specialized for particular domains, which operate fast and mandatorily, are hard-wired for a particular area of the brain, their structure and function largely innately determined, and they are informationally encapsulated. Fodor's view on language is that it is an (i) input system analogous to those devoted to the senses, (ii) the central system, however, is unstructured and uninvestigable.[8] By contrast, Chomsky assumes that language is a central system used in both input and output (in expressing and communicating thoughts), and there are probably several such central systems: a language faculty; a number "sense," and possibly others (see e.g. Fodor 2000, Smith and Allott 2016, and Chomsky 2018 on similarities and differences between their views).

While the framework of GB led to very rich empirical generalizations and discoveries (see also the chapters by Baker, Müller, Sheehan, Chapters 10–12, in this volume), there are some issues with its architecture. In particular the proliferation of internal modules and the fact that it postulates four levels of representation can be seen as violating the principle that one should only postulate the "barest essentials" necessary for a theory of grammar. In addition, a new question on the agenda became how to account

for the biological or evolutionary origin of language: To what extent is our theory of human language compatible with what we know about language evolution and the biological scaffolding of language? We turn to a discussion of these issues in the next section.

3.5 The Minimalist Program: Untying the Descriptive vs. Explanatory Knot

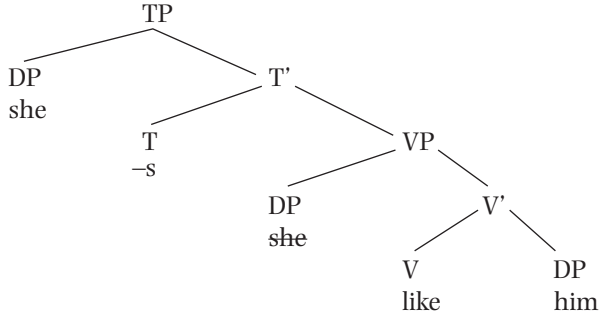
As the principles of GB were increasingly refined, the theory also became more complex. In lectures towards the end of the 1980s, Chomsky started asking whether the theoretical model could be rationalized in the sense of unifying, including eliminating, principles while maintaining, or possibly improving, empirical coverage (cf. Chomsky 2000, p. 93; Freidin and Vergnaud 2001, p. 642). This became the beginning of the Minimalist Program. Chomsky (1993) is the first paper that is written from an explicit Minimalist perspective and one of the cases discussed there provides a helpful illustration of the underlying logic. Example (18) deals with case, which is not very conspicuous in English, but which can be seen in pronouns.

(18) a. Sara/John likes **him/her**.
b. **She/he** likes him/her.
c. Sara proved [**him** right]

As (18a) and (18b) show, pronoun subjects occur in nominative case and pronoun objects occur in accusative case, which of course are relics of the full-fledged morphological case system in older varieties of English. (18c) shows that accusative case can also occur in other environments. This raises the interesting question of how case assignment works – what are the configurations in which case licensing occurs?[9] In GB, the structural representations underlying the bolded items in (18) are all different, though attempts had been made to use one principle (government) to account for all of them (Uriageka 1988, 2012). Before we can consider the argument, we need to do a brief detour to introduce some core concepts of phrase structure (see section 3.6.2 below, and Lasnik and Lohndal 2013 for a much more detailed treatment, including the historical development of phrase structure within generative grammar).

Consider the simplified structure in (19), where we are not illustrating the inner structure of the nominal phrase (called DP; see immediately below).

(19)



This is an instance of the X-bar schema (Chomsky 1970, 1986, Stowell 1981), a structural blueprint for syntactic structure. The schema contains a unified structure for each phrase: The phrase has a head (i.e. the phrase is endocentric), it has a complement as the sister of the head, and then a specifier is the "subject" of the combined unit of head and complement. (19) has three phrases: the verb phrase (VP), the tense/agreement phrase (TP), and the determiner phrase (DP). If we apply this to VP, that means that V is the head of the verb phrase, *him* is the complement of the verb, and *she* is the specifier of the verb. The subject then moves to the canonical subject position in English, which is called the specifier position of T, or SpecTP for short (strikethrough marks that the constituent is not pronounced).[10] The tense and agreement morphology starts out as the head of TP and then gets unified in the morphology with the verb stem *like*. Now we are ready to go back to the problem posed by the data in (18).

In (19), *she* is in the specifier position of T, which is the locus of nominative case. Rather differently, *him* is the complement of the verb, which is to say that accusative case is licensed in that position. As for (18c), this is an exceptional case marking construction, since *him* is licensed in the specifier position of an embedded constituent. These environments for licensing case all look very different. Instead, Chomsky (1993) proposes that case licensing occurs in one type of configuration called a specifier-head configuration. Just like the subject position seems to be an agreement configuration (as subject–verb agreement shows), Chomsky proposes that there is a similar agreement configuration for the object, except that this agreement is not visible in languages like English. This makes it possible to say that case licensing of the accusative is very similar in (18a) and (18c) despite surface differences suggesting the opposite conclusion. That is, at some point in the derivation the object and verb must stand in a specifier-head relation so that Case can be assigned. Different variants of the view have proposed different points in the derivation where this would be achieved.[11]

As Lohndal and Uriagereka (2014, 510) point out, this example makes the logic of the Minimalist Program clear: (i) Assume that the basic theoretical and empirical postulates of GB Case theory are correct: lexical items get case, certain syntactic heads carry the ability to provide case to a lexical item, and case licensing occurs in certain positions. (ii) The domains in which case licensing occurs are very different. (iii) A new theory offers a novel take on what a case licensing configuration is: specifier-head configurations, which are independently needed to account for subject–verb agreement in languages like English. Put differently, you pick a domain which is fairly well understood, you question some of the core parts of the analysis, and then you seek to develop a new and more principled and economic analysis (true to the Galilean ideal that has shaped much of Chomsky's work; see Allott, Lohndal & Rey, Chapter 33 this volume, for further discussion).

Another area that Chomsky (1993) targeted concerned larger architectural aspects, namely the components of the grammar. In GB, the grammatical architecture had the structure depicted in (17). This architecture contains a certain amount of overlap between D-structure and LF on the one hand, and S-structure and PF on the other hand (see Hornstein, Nunes, and Grohmann 2005 for much more discussion). D- and S-structure are clearly more grammar-internal than PF and LF, given that each sentence needs to receive a semantic encoding and a sound (or sign, as in the case of sign languages) encoding. Chomsky (1993) sets out to investigate whether these grammar-internal levels in the derivation could be eliminated. He reasons as follows:

> Each derivation determines a linguistic expression, an SD [Structural Description], which contains a pair (π, λ) meeting the interface conditions. Ideally, that would be the end of the story: each linguistic expression is an optimal realization of interface conditions expressed in elementary terms (chain link, local X-bar-theoretic relations), a pair (π, λ) satisfying these conditions and generated in the most economical way. Any additional structure or assumptions require empirical justification (Chomsky 1993, p. 4).

And since this paper, D-structure and S-structure have no longer been part of the grammatical component. Rather, the interfaces, sound and meaning, are regarded as the essential components, as Chomsky (2000, p. 91) argues:

> On these assumptions we understand L[anguage] to be a device that generates expressions Exp = <Phon, Sem>, where Phon provides the "instructions" for sensorimotor systems and Sem the "instructions" for systems of thought – information about sound and meaning, respectively, where "sound" and "meaning" are understood in internalist terms, "externalizable" for language use by the performance systems.

The emphasis on interfaces raises many new questions: What is the division of labor between the core syntax and the interfaces? How are the interfaces actually structured (see Uriagereka 2008, Samuels 2012, Lohndal 2014, among several, on the latter)?

Many other examples of minimalist reasoning could be provided as well. An excellent textbook exposition can be found in Hornstein, Nunes, and Grohmann (2005), and we refer the reader to this for more in depth discussion and a rich array of examples.

The minimalist reasoning is in part an application of Occam's Razor, what Martin and Uriagereka (2000) have labeled "methodological minimalism":

> What one might call a "weak minimalist thesis" is nothing new. The drive for simple and nonredundant theories of the world (or Occam's razor) is taken for granted in the core sciences. Even within the more specialized science of linguistics, this working methodology has brought undeniable success. From such a perspective, minimalism is just a new way to refer to what many people have been doing for a long time: seeking the best way to theorize about a particular domain of inquiry. We think of this thesis as *methodological minimalism*. (Martin and Uriagereka 2000, p. 1)

However, minimalism can also be viewed in a different sense, what Martin and Uriagereka (2000) label "ontological minimalism." As Chomsky (2000, 92) points out, progress has made it "possible to consider some new questions about [the] F[aculty of]L[anguage]. In particular, we may ask the question, how well is FL designed?" The idea is that language design may be optimal, "approaching a "perfect solution" to minimal design specifications" (Chomsky 2000, 93). The latter is known as the Strong Minimalist Thesis (SMT). Chomsky is the first to stress that it would be surprising if the conclusion holds true, yet it would carry significant implications if true. As such, the reduction and unification that characterize minimalism are also motivated by the SMT. It is not just a question of reducing or dispensing with grammar-internal levels, but with that comes the gain that the architecture only encompasses the virtually conceptually necessary interfaces, those that a theory of I-language cannot do without. This is all motivated by the quest to understand why certain principles of the language faculty hold and not others (Chomsky 2000, p. 92; Chomsky 2004). This type of why-question is characteristic of the Minimalist Program, and Chomsky (2000) emphasizes that they are extraordinarily difficult to answer:

> Questions of this kind are not often studied and might not be appropriate at the current level of understanding, which is, after all, still quite thin in a young and rapidly changing approach to the study of a central component of the human brain, perhaps the most complex object in the world, and not well understood beyond its most elementary properties (Chomsky 2000, p. 93).

As a consequence of this quest, other properties of the mind/brain have become more prominent (cf. Boeckx and Uriagereka 2006, p. 542). Chomsky (2005) emphasizes that there are in principle three factors that, in some combination, determine the adult language system: "Assuming that the faculty of language has the general properties of other biological systems, we should, therefore, be seeking three factors that enter into growth of language in the individual" (Chomsky 2005, p. 6). These three factors are provided in (20).

(20) a. Genetic endowment specific to language
b. Experience
c. Principles not specific to the faculty of language

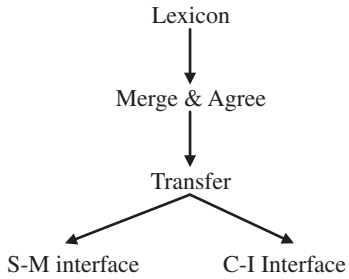
The first part is what is often referred to as Universal Grammar (UG): it is whatever the genetic endowment is for acquisition of human language to take place. Furthermore, it is obvious that experience plays a role, given that a child growing up in Beijing acquires Mandarin Chinese and a child growing up in Athens acquires Greek. The last factor encompasses principles that are not specific to Universal Grammar. Chomsky argues that principles of data analysis may be among such principles, and also:

> […] principles of structural architecture and developmental constraints that enter into canalization, organic form, and action over a wide range, including principles of efficient computation, which would be expected to be of particular significance for computational systems such as language (Chomsky 2005, p. 6).

As Lohndal and Uriagereka (2017, p. 117) point out, these factors are very similar to the three factors that hold for organisms more generally (cf. Gould 2002, p. 259 on the "adaptive triangle"). That said, it is not trivial to develop specific proposals for what the third factors actually are; see Lohndal and Uriagereka (2017) for comprehensive discussion. However, this focus on third factors has also led to a reduced emphasis on the role of Universal Grammar, hence, for example, Chomsky (2007) has the title "approaching UG from below." This is a marked shift compared to GB, where concerns about the size of Universal Grammar were nonexistent. If a property is innate, it does not have to be somehow learned from the environment, so a big UG is compatible with taking arguments from the poverty of the stimulus seriously (see Crain, Giblin and Thornton, Chapter 29 of this volume). In recent minimalism, the goal is to reach explanatory adequacy while attributing as little as possible to UG. Another reason for this shift is the concern for biological and evolutionary adequacy, which characterizes minimalism. It is hard to see how all the separate parts (and their interrelationships) of the GB system could or would have evolved. How did the uniquely human ability for language arise in the species? The evolutionary literature is by now very rich and multiple proposals have been advanced (for reviews, see Fitch 2010; Reboul, Chapter 30 of this volume). Even though minimalism does not offer a single answer to the question, the question itself has shaped a lot of research within minimalism, e.g. the increased emphasis on third factor effects.

The architecture of the grammar in minimalism is illustrated in (21).

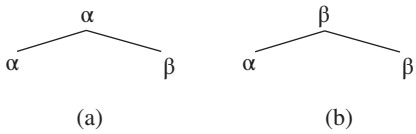
(21)



Let us consider this computational system in a bit more detail.

There is a lexicon, just as in GB and previous approaches. Based on whatever is in the lexicon, there is one basic mechanism that creates structure: Merge puts two items together, say, α and β, and that generates the set {α, β}, which typically then has α or β as its label: {α, {α, β} or {β, {α, β}}(Chomsky 1995). This, then, is the way to implement labeling in terms of (unordered) sets. More traditional tree structure representations are provided in (22).

(22)



Further items can be added and merged with α or β to generate binary-branching structures. This accounts for the creative linguistic ability that all humans possess. Merge comes in two different "flavors": *external merge,* which is the first time an item is merged into a structure, and *internal merge,* which means that, say, α is merged again later in the structure (hence accounting for displacement phenomena) (Chomsky 2004; see Svenonius, Chapter 9 of this volume, for extensive discussion). Importantly, both ways of applying merge are manifestations of the same operation. The Extension Condition is a principle that holds that all trees are extended at the top, meaning that new lexical items from the lexicon have to be merged on top of the existing structure, they cannot be "tucked into" existing structure (Chomsky 1995).

In addition to merge, there is at least the operation Agree, which is an abstract mechanism of dependency-formation. More specifically, the role of Agree is to ensure that syntactic features are checked or licensed. This is important in order to achieve descriptive adequacy, notably when it comes to constraining the grammar, since we know that dependency-formation is heavily constrained across languages. A simple example of dependency-formation when it comes to features can be seen in English subject–verb agreement as in (23).

(23) a. They are happy.
b. She is happy.
c. I am happy.

Subject–verb agreement is the morphological expression of an abstract syntactic relationship between the verb and the subject, since, as (23) illustrates, they have to agree in

the features [NUMBER] (singular and plural) and [PERSON] (1, 2, 3). Agree is the mechanism that ensures that, say, the features of *they* match the features on the verb (see Adger 2003 for a textbook illustration). Notably, it is assumed that pronouns (and other nominals) carry number and person features that are interpreted at the C-I interface, whereas similar features on verbs are not interpreted by the C-I interface. For that reason, such features are uninterpretable, even though they can be morphologically realized, as in the case of English subject–verb agreement.

As structures are generated, they are at various points transferred to the two interfaces: the sensorimotor interface ("sound") and conceptual-intentional interface ("meaning"). That is, pieces of syntactic structure (called "phases" within minimalism) are transferred to the interfaces and there given the necessary interpretation at both interfaces. Space does not allow us to elaborate on phases, but see Gallego (2012) for an extensive presentation.

The Minimalist Program is a program, meaning that it comes in different guises. As Chomsky (2000, 92) puts it: "[t]here are minimalist questions, but no minimalist answers, apart from those found in pursuing the program, perhaps that makes no sense, or that it makes sense but is premature." Chomsky has never provided a more theoretical foundation of the notion of a program, but Boeckx (2006) does so by pointing to work by Lakatos (1968, 1970) and others. Lakatos argues that research programs have a core, a set of principles that the scholar has to adhere to. In addition, auxiliary assumptions are made, which often vary from one timeslice of the theory to another. The latter are often oversimplifications that the researcher knows are not true, but yet are made in order to be able to provide sufficiently detailed analyses of a set of phenomena. Because of this, Lakatos argues that the rigor of a research program may not at first be great, and that maturation is often slow. Relevantly for some of the criticism leveled against generative work, namely that there are so many counterexamples to proposed principles or generalizations, Lakatos has a specific view on the role of falsification: "A corroborated falsifying hypothesis does not have sufficient power to enable a counterexample to eliminate a theory. If it had, we would eliminate all science instantly" (Lakatos 1968, 163). And he continues:

> A counterexample, in order to *reject*, to *eliminate* a theory, needs more powerful support than that which a lower-level falsifying hypothesis can provide: it needs the support of a theory with more corroborated content, with wide explanatory power. *There must be no elimination without the acceptance of a better theory* (Lakatos 1968, 163; his italics).

In this regard, Lakatos differs from Popper: "[…] in my conception criticism does not – and must not – kill as fast as Popper imagined. *Purely negative, destructive criticism, like "refutation" or demonstration of an inconsistency does not eliminate a programme*" (Lakatos 1968, 183; his italics). This conception fits very well with how research within the Minimalist Program has taken place: It has been exploratory and continued despite obvious empirical or theoretical issues that needed to be fixed.

Boeckx (2006) and others argue that this programmatic nature of the Minimalist Program is a good thing. It allows researchers to pursue a multitude of approaches within the larger umbrella of minimalism. Put differently, it is possible to assume lexicalism (e.g. Chomsky 1995: chapter 4, Williams 2007), distributed morphology (Embick and Noyer 2007, Embick 2015), cartography (Rizzi 1997, Shlonsky 2010), or an exo-skeletal approach (Borer 2005a, b, 2013, Lohndal to appear). Within each

version, a substantial body of work has emerged and the versions are developing fairly independently of each other. At the same time, it makes it hard to pin down exact criteria that can be used to label a particular scholar a minimalist. It also differs to what extent a particular scholar considers his or her work minimalist in nature, in particular in the ontological sense identified by Martin and Uriagereka (2000). However, it should be pointed out that some argue that minimalism should start producing what they label "theories," here summarized by Lohndal and Uriagereka (2014, 520):

> Some scholars have argued that it is time to produce theories that can be evaluated and falsified (see, e.g. Hornstein 2009). Soon after the [minimalist program] was initiated, Lasnik (1999: p. 6) stated that "there is not yet anything close to a Minimalist theory of language." Differences in the underlying philosophy of science will in part determine whether a scholar regards programs as sufficient or whether theories are required for genuine progress (Lohndal and Uriagereka 2014, p. 520).

This raises obvious and thorny questions about what the difference between a program and a theory may be, issues that we cannot go into here.

That concludes our fairly brief overview of the general nature of the Minimalist Program. In the next section, we continue our discussion of this program by turning to some current tendencies.

3.6 Current Tendencies

In this section, we will try to outline some of the current research trends within the Minimalist Program. A range of issues are just as important today as they have always been: Poverty of the Stimulus (see Crain, Giblin, and Thornton, Chapter 29 of this volume), structure dependent rules, UG, constraints on dependencies (see Müller, Chapter 12 of this volume). Nevertheless, there are certain areas to which the searchlight is currently oriented. Some of these are discussed in other chapters, notably language evolution (Reboul, Chapter 30 of this volume) and an increased emphasis on comparative grammar (Sheehan, Chapter 11 of this volume). For that reason, we won't discuss these here. Rather, we will focus on three other topics: Features, the nature of phrase-structure representations (viz. labels and labeling), and extensions of the formal framework to new areas.

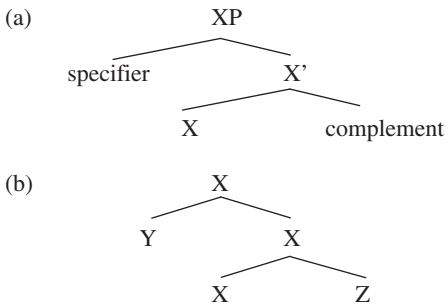
3.6.1 Features and the Hierarchy of Features

It has been pointed out in recent literature that there is a tension between minimalism and the cartographic approach put forth by Rizzi (1997) and Cinque (1999). While minimalism argues for a minimal role of UG, the cartographic model assumes a very rich system of features, organized in one rich functional hierarchy. An oft-cited example is the following, which is Cinque's (1999, p. 106) proposal for a universal sequence of functional heads that host adverbials in their specifiers. The lexical items here are intended as examples of each category, and there is an Italian example (*tutto*) because there is no English example of this category.

(24) [*frankly* $\text{Mood}_{\text{speech act}}$ [*luckily* $\text{Mood}_{\text{evaluative}}$ [*allegedly* $\text{Mood}_{\text{evidential}}$ [*probably* $\text{Mod}_{\text{epistemic}}$ [*once* T(Past) [*then* T(Future) [*perhaps* $\text{Mood}_{\text{irrealis}}$ [*necessarily* $\text{Mod}_{\text{necessity}}$ [*possibly* $\text{Mod}_{\text{possibility}}$ [*usually* $\text{Asp}_{\text{habitual}}$ [*again* $\text{Asp}_{\text{repetitive(I)}}$ [*often*

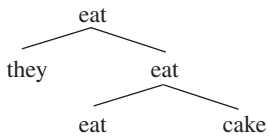
$\text{Asp}_{\text{frequentative(I)}}$ [*intentionally* $\text{Mod}_{\text{volitional}}$ [*quickly* $\text{Asp}_{\text{celerative(I)}}$ [*already* T(Anterior) [*no longer* $\text{Asp}_{\text{terminative}}$ [*still* $\text{Asp}_{\text{continuative}}$ [*always* $\text{Asp}_{\text{perfect(?)}}$ [*just* $\text{Asp}_{\text{retrospective}}$ [*soon* $\text{Asp}_{\text{proximative}}$ [*briefly* $\text{Asp}_{\text{durative}}$ [*characteristically(?)* $\text{Asp}_{\text{generic/progressive}}$ [*almost* $\text{Asp}_{\text{prospective}}$ [*completely* $\text{Asp}_{\text{SgCompletive(I)}}$ [*tutto* $\text{Asp}_{\text{PlCompletive}}$ [*well* Voice [*fast/early* $\text{Asp}_{\text{celerative(II)}}$ [*again* $\text{Asp}_{\text{repetetive(II)}}$ [*often* $\text{Asp}_{\text{frequentiative(II)}}$ [*completely* $\text{Asp}_{\text{SgCompletive(II)}}$]]]

(26)



Within X-bar theory, the positions were fixed: A specifier is a sister to *X'* (read: X-bar), and a complement is a sister to a head. In Bare Phrase Structure, all notions are relational, as can be seen in (26b) as all *X*s are formally identical. The reasoning behind this shift was that phrase structure representations should not introduce anything beyond what is already in the lexicon, and bar-levels are not in the lexicon. Therefore, a verb phrase could look as in (27).[12]

(27)

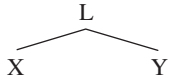


In (27), nothing beyond the lexical items are part of the representation and whether or not *they* is a specifier or a complement is something that is determined relationally (Chomsky 1995).

The change from X-bar theory to bare phrase structure was seen as a major success, yet in the past 5–10 years, Chomsky has once again pushed the research frontiers by focusing on the labels themselves and on whether or not the algorithms need to incorporate facts about endocentricity or not. In previous models, each phrase had a head, thereby deriving endocentricity. In Chomsky's recent developments, endocentricity is still important for the syntactic derivation and to the interface systems, yet endocentricity is not a fundamental property of phrase structure qua phrase structure.

In deconstructing endocentricity, Chomsky has directed attention to the role of phrase structural labels: Are they needed (cf. Collins 2002), and if they are needed, at which level of the grammar may they be needed, i.e. what role do they play in syntactic derivations? As we have seen above, in Chomsky (1995), the operation *merge* yielded a labeled syntactic structure. That is, merge(X,Y) yields {L, {X, Y}} where L ∈ {X, Y}.

(28)



However, adding the label is an extra assumption, merge in its simplest form takes only two objects and puts them together: there is no labeling (Chomsky 2013, 2015, Chomsky, Gallego, and Ott 2019, Collins 2017). Thus, it should be scrutinized carefully to see whether its existence is properly motivated. Chomsky (2013) argues that the

simplest merge needs to be supplemented with another operation, which he calls *Label*. Essentially, this provides a way in which some of the effects of labeling can be accounted for, without postulating that constituents are ever labeled. This operation locates the "structurally most prominent lexical item" within a syntactic object (Chomsky, Gallego, and Ott 2019, 247). For instance, if we have the syntactic object {H, XP}, where H is a lexical item and XP is a complex object, then H will be the most prominent lexical item. The latter follows from H carrying a feature that can be located by the search algorithm as the most prominent item, which is to say that prominence is really determined by particular features. Since the search algorithm is always looking for the closest possible target, the features of H will be more prominent than the features embedded within the XP.

Chomsky and others have developed this approach to labeling in order to account for a variety of empirical patterns, ranging from movement, constraints on movement, and also diachronic change (see van Gelderen, Chapter 13 of this volume). We cannot do justice to the rich technical details surrounding labels and labeling, except make the point that this has become a core area of current developments and that once again Chomsky has provided important contributions in shaping this research.

3.6.3 Extensions of the Theory: Multilingualism

Chomsky (1965) defined the focus of most formal linguistics when he argued the following:

> Linguistic theory is concerned primarily with an ideal speaker–listener, in a completely homogeneous speech-community, who knows its language perfectly and is unaffected by such grammatically irrelevant conditions as memory limitations, distractions, shifts of attention and interest, and errors (random or characteristic) in applying his knowledge of the language in actual performance (Chomsky 1965, p. 3).

Put differently, the monolingual speaker has been given the primary role in formal (and many nonformal) investigations of language (cf. Benmamoun, Montrul, and Polinsky 2013). Concretely, when a native speaker Y of language X is asked to provide judgments on strings of words, the researcher has deliberately ignored the fact that Y may also know other languages to various degrees. It has been argued that this kind of simplification made it possible to create new theories of hitertho unattested complex empirical patterns (Lohndal 2013).

There are several reasons why formal grammar would want to extend its empirical and theoretical scope. Speakers who know multiple languages to different degrees provide another type of data which in turn present new theoretical opportunities. They come in different guises, ranging from balanced multilingual speakers to receptive heritage speakers who are able to understand their heritage language but not produce it.[13] Given that a core objective in Chomskyan generative grammar is to model what a possible mental grammar is, data from multilingual speakers are extremely relevant (cf. Alexiadou and Lohndal 2016). These speakers also provide examples of what a possible grammar is, which is to say that the ecological validity of generative grammar is increased if it is able to account for what is after all the most common phenomenon today – namely that of being multilingual in one way or other (cf. Kupisch, Soares, Puig-Mayenco, and Rothman, Chapter 15 of this volume).

With this as a backdrop, it should be added that Chomskyan generative grammar was extended fairly early on to situations and phenomena that do not fit the description in the quote above. Slabakova (Chapter 14 of this volume) shows this for second language learning, where substantial and crucial work especially started to emerge in the 1980s. However, multilingualism more generally has become much more prominent (cf. Kupisch, Soares, Puig-Mayenco, and Rothman, Chapter 15 of this volume), in particular work on heritage languages (Polinsky 2018; Polinsky and Scontras 2020 make this vivid) and also work on code switching as an attempt to differentiate different formalisms. We will provide one example from the area of code switching and grammatical gender.

There has been a lot of discussion of how grammatical gender should be analyzed in the literature. Issues range from the nature of gender assignment to the syntactic location of gender features in the syntactic representation (see, among many others, Corbett 1991; Kramer 2016). The traditional assumption is that a gender feature is simply part of the lexical representation of a *word*. However, recent theoretical work has questioned this idea and also the idea that words are the grammatically relevant unit. Instead, words are epiphenomenal, a result of the syntactic derivation. In particular, Distributed Morphology has promoted the idea that the smallest units in a syntactic derivation are roots and functional elements that among others provide roots with a syntactic category (Marantz 1997; Alexiadou 2001; Arad 2003; Embick and Marantz 2008; Embick 2015). As an example, consider (29). In (29a), a root merges with a *v* to form a verb, and in (29b), the same root merges with an *n* to form a noun.

(29) $[_{v}\ v\ \sqrt{\text{ROOT}}\ ]$ b. $[_{n}\ n\ \sqrt{\text{ROOT}}\ ]$

A root has to be merged in order to ensure that a category is assigned. Embick and Marantz (2008: 6) label this *the categorization requirement*. In her comprehensive approach to grammatical gender, Kramer (2015) argues that *n* is the locus of gender assignment. If true, that means that gender is syntactically assigned. This has important ramifications for understanding language mixing involving grammatical gender. For instance, in American Norwegian, a heritage language of Norwegian spoken in the United States (see Haugen 1953), speakers easily assign grammatical gender to nouns borrowed from English, i.e. masculine, feminine, or neuter gender; (30) provides some examples, where the English items are in boldface (Grimstad, Riksem, Lohndal, and Åfarli 2018, p. 198).

(30) a. en **blanket**
a.M blanket
'a blanket'
b. ei **nurse**
a.F nurse
"a nurse"
c. et **crew**
a.N crew
"a crew"

As Grimstad, Riksem, Lohndal, and Åfarli (2018, 198) point out, the genders on English items are not identicial to the translational equivalents in Norwegian. The question is what determines gender assignment for English words in American Norwegian.

Arguing that speakers have one lexical representation with, say, *blanket* carrying a masculine gender feature, and one without such a feature, simply pushes the problem back: How come speakers have acquired two lexical representations where one has grammatical gender and the other does not? Instead, Grimstad, Riksem, Lohndal, and Åfarli (2018) make the case that gender is assigned syntactically. Following Kramer's (2015) specific implementation, gender features would be on *n* (cf. (29b)), meaning that if *n* has a gender feature and the root is an English root, then we get e.g. *en blanket,* as in (28a). The structures in (31) illustrate what this would look like for the three nouns in (30).

(31) a. $[_{n}\ n_{[\text{MASCULINE}]}\ \sqrt{\text{BLANKET}}\ ]$
b. $[_{n}\ n_{[\text{FEMININE}]}\ \sqrt{\text{NURSE}}\ ]$
c. $[_{n}\ n_{[\text{NEUTER}]}\ \sqrt{\text{CREW}}\ ]$

The major advantage of this analysis is that if gender were specified on the roots themselves, then multiple lexical entries for each root would be required. In contrast, the distributed approach in (31) allows the same root to be combined with any gender-flavor of *n*, and the data from American Norwegian support this variability since several speakers assign a different gender to the very same root. There are certain patterns in how gender assignment works, e.g. phonological similarity with Norwegian words has been argued by Haugen (1953) to be a factor. Space does not allow us to expand on this analysis any further, but it demonstrates how data from multilingual speakers have become rather important in developing formal analyses of, say, grammatical gender and what the units of word formation actually are; see Alexiadou and Lohndal (2018) for further discussion.

3.7 Conclusion

The ongoing development of generative grammar is a testament to Chomsky's extraordinary ability to set the research agenda and continuously ask new questions and thereby sharpen our tools so that we get an ever-better understanding of the unique human ability for language. In terms of the larger conceptual issues, there have been some changes over the years. An example is the change from Government and Binding to the Minimalist Program when it comes to approaching Universal Grammar: Do scholars assume that Universal Grammar is whatever it needs to be to account for the data, or do they instead assume that it should be as minimal as possible, in particular to get a possible handle on the evolutionary origin of the human ability for language? With the shift to the latter position, Chomsky has also positioned generative grammar better for interactions with research into cognition more generally.

Endnotes

1 This chapter was written as part of the international research project *MultiGender* at the Centre for Advanced Study at the Norwegian Academy of Science and Letters in Oslo during the academic year 2019–2020, where both authors were fellows. We are grateful to an anonymous reviewer for very helpful comments on a previous version, and to Nicholas Allott for very detailed feedback. AL 554/8-1 (Alexiadou) is also hereby acknowledged.

2 Chomsky (1965, 4) emphasizes the importance of developing explicit theories. In doing so, he contrasts generative grammar with traditional grammars. The latter provide a lot of structural information, but they do not offer mechanisms that can account for the "regular and productive syntactic processes." Such mechanisms are implicit as these traditional grammars presuppose that speakers and listeners have such knowledge. That is, speakers know where to put the finite verb in a *yes/no* question, but an explicit theory should explain the rule that governs how the finite verb *can* in *Can flying eagles swim?* becomes the first constituent. Importantly, trying to be explicit also raises new questions, such as why *Can eagles that fly swim?* is a question about the swimming ability of flying eagles, not the other way around. Such new questions have continuously led to novel generalizations about languages and language in general.

3 Since then, two additional questions have also been put on the agenda (cf. Boeckx 2006):

(i) (a) How is that knowledge implemented in the brain?
(b) How did that knowledge emerge in the species?

We will not discuss the first of these further here, but see Zaccarella and Trettenbein (Chapter 20 of this volume). We briefly discuss the latter in Section 3.5.

4 It is important to note that "knowledge" incorporated into mental systems need not be true. However, when it comes to each person's internal grammar, the question of truth does not really make sense. Furthermore, it is unclear whether knowledge needs to be believed. For sure, it does not have to be consciously available or integrated with general reasoning. Lastly, it does not have to be stored and retreivable (i.e. *represented* in the philosophers" sense): It may be simply embodied/instantiated by the workings of a particular system (here the I-language). See Allott and Smith (Chapter 34 of this volume).

5 Note that in principle the linguistic theory should help explain any linguistic behavior, not just intuitions. See Gross (Chapter 35 of this volume) for further discussion.

6 It should be pointed out that Hankamer (1973) argued that the constraint in question was universal, but given cross-linguistic variability in sluicing, that cannot be the case.

7 In the early stages of transformational grammar (Chomsky 1965), it was postulated that an *evaluation metric* helps the learner decide which grammar, amongst different ones which can all provide structural descriptions for the available primary linguistic data (PLD), is the optimal one. In terms of the evaluation metric, the core grammar is an optimal system.

8 This should not be taken to suggest that Fodor was committed to language being either a peripheral system or uninvestigable. Essentially, Fodor took for granted that the language faculty was essentially a database. See Allott and Smith (Chapter 34) for much discussion.

9 In GB, a fundamental difference is introduced between case and Case, where the latter denotes what is called abstract Case; a syntactic Case feature which is not phonologically realized. An example would be *Sara* and *John* in (i), *Sara* is assumed to have abstract nominative Case whereas *John* has abstract accusative Case – despite there being no morphological marking of case.

(i) Sara loves John.

Abstract Case was first proposed by Vergnaud (1977) and further developed by Chomsky (1981). Note also that the literature typically distinguishes between Case *assignment* and Case *checking*, a difference we set aside here, but see Lasnik (2008, 24) for an overview and a historical perspective.

10 Evidence that this movement is necessary comes from facts about where adverbs and negation are placed. Semantically they modify the entire verb phrase, so they are inserted above the VP in the structure. Since the subject needs to precede the adverb, not follow it, as it would have if it did not move to SpecTP.

(i) (a) She often likes him.
(b) She does not like him.

11 Implementations differ in terms of how this is done technically. Chomsky (1993) proposed covert movement at LF, whereas others have argued that there is displacement overtly of

the object, but that the verb moves even higher (so as to precede the object on the surface) (Postal 1974, Lasnik and Saito 1991, Koizumi 1995, and much later work).

12 Setting aside higher functional material such as tense, and also any internal projection involving *they* and *cake*.

13 Rothman (2009b, 156) defines a heritage language and a heritage speaker as follows:

> A language qualifies as a heritage language if it is a language spoken at home or otherwise readily available to young children, and crucially this language is not a dominant language of the larger (national) society. […] [A]n individual qualifies as a heritage speaker if and only if he or she has some command of the heritage language acquired naturalistically […] although it is equally expected that such competence will differ from that of the native monolinguals of comparable age.

References

Adger, D. 2003. *Core Syntax*. Oxford: Oxford University Press.

Alexiadou, A. 2001. *Functional Structure in Nominals*. Amsterdam: John Benjamins.

Alexiadou, A., and E. Anagnostopoulou. 1998. Parametrizing AGR: word order, verb- movement and EPP-checking. *Natural Language and Linguistic Theory* 16: 491–539.

Alexiadou, A., and T. Lohndal. 2016. Editorial: The Grammar of Multilingualism. Frontiers in Psychology, doi.org/10.3389/fpsyg.2016.01397.

Alexiadou, A., and T. Lohndal. 2018. Units of language mixing: A cross-linguistic perspective. Frontiers in *Psychology*, doi.org/10.3389/fpsyg.2018.01719.

Arad, M. 2003. Locality Constraints on the Interpretation of Roots: The Case of Hebrew Denominal Verbs. *Natural Language and Linguistic Theory* 21: 737–778.

Baker, M. 2008. The microparameter in a microparametric world. In *The Limits of Syntactic Variation*, edited by T. Biberauer, 351–374. Amsterdam: John Benjamins.

Benmamoun, E., S. Montrul, and M. Polinsky. 2013. Heritage languages and their speakers: Opportunities and challenges for linguistics. *Theoretical Linguistics* 39: 129–181.

Boeckx, C. 2006. *Linguistic Minimalism*. Oxford: Oxford University Press.

Boeckx, C. 2013. *Syntactic Islands*. Cambridge: Cambridge University Press.

Boeckx, C., and J. Uriagereka. 2006. Minimalism. In *The Oxford Handbook of Linguistic Interfaces*, edited by G. Ramchand and C. Reiss, 541–573. Oxford: Oxford University Press.

Borer, H. 2005. *Structuring Sense, Volume 1: In Name Only*. Oxford: Oxford University Press.

Borer, H. 2005b. *Structuring Sense, Volume 2: The Normal Course of Events*. Oxford: Oxford University Press.

Borer, H. 2013. *Structuring Sense, Volume 3: Taking Form*. Oxford: Oxford University Press.

Brame, M. K. 1976. *Conjectures and Refutations in Syntax and Semantics*. New York: Elsevier.

Chomsky, N. 1955. The logical structure of linguistic theory. Ms. Harvard University and MIT. [Revised version published in part by Plenum, New York, 1975].

Chomsky, N. 1965. *Aspects of the Theory of Syntax*. Cambridge: MIT Press.

Chomsky, N. 1970. Remarks on nominalization. In *Readings in English Transformational Grammar*, edited by R. A. Jacobs, and P. S. Rosenbaum, 184–221. Waltham, MA: Ginn.

Chomsky, N. 1973. Conditions on transformations. In A Festschrift for Morris Halle, edited by S. Anderson, and P. Kiparsky, 232–286. New York: Holt, Rinehart and Winston.

Chomsky, N. 1975. *Reflections on Language*. New York: Pantheon.

Chomsky, N. 1980. *Rules and Representations*. New York: Columbia University Press.

Chomsky, N. 1981. *Lectures on Government and Binding*. Dordrecht: Foris.

Chomsky, N. 1986. *Knowledge of Language: Its Nature, Origin and Use*. New York: Praeger.

Chomsky, N. 1993. A Minimalist Program for linguistic theory. In *The View from Building 20*, edited by K. Hale, and S. J. Keyser, 1–52. Cambridge: MIT Press.

Chomsky, N. 1995. *The Minimalist Program*. Cambridge: MIT Press.

Chomsky, N. 2000. Minimalist inquiries: The framework. In *Step by Step: Essays on Minimalist Syntax in Honor of Howard Lasnik*, edited by R. Martin, D. Michaels, and J. Uriagereka, 89–155. Cambridge: MIT Press.

Chomsky, N. 2001. Derivation by phase. In *Ken Hale: A Life in Language*, edited by M. Kenstowicz, 1–50. Cambridge: MIT Press.

Chomsky, N. 2004. Beyond explanatory adequacy. In *Structure and Beyond: The Cartography of Syntactic Structures*, edited by A. Belletti, 104–131. Oxford: Oxford University Press.

Chomsky, N. 2005. Three factors in language design. *Linguistic Inquiry* 36: 1–22.

Chomsky, N. 2007. Approaching UG from below. In *Interfaces + Recursion =Language?*, edited by H-M. Gärtner, and U. Sauerland, 1–29. Berlin: Mouton de Gruyter.

Chomsky, N. 2008. On phases. In *Foundational Issues in Linguistic Theory*, edited by C. Otero, R. Freidin, and M-L. Zubizarreta, 133–166. Cambridge, MA: MIT Press.

Chomsky, N. 2013. Problems of projection. *Lingua* 130: 33–49.

Chomsky, N. 2015. Problems of projection: Extensions. In *Structures, Strategies and Beyond*, edited by E. Di Domenico, C. Hamann, and S. Matteini, 1–16. Amsterdam: John Benjamins.

Chomsky, N. 2018. Two notions of modularity. In *On Concepts, Modules, and Language: Cognitive Science at Its Core*, edited by R. G. de Almeida, and L. R. Gleitman, 25–40. Oxford: Oxford University Press.

Chomsky, N., Á. J. Gallego, and D. Ott. 2019. Generative grammar and the Faculty of Language: Insights, questions, and challenges. *Catalan Journal of Linguistics Special Issue*: 229–261.

Chomsky, N., and H. Lasnik. 1977. Filters and control. *Linguistic Inquiry* 8: 425–504.

Chomsky, N., and H. Lasnik. 1993. The theory of Principles and Parameters. In *Syntax: An International Handbook of Contemporary Research*, edited by J. Jacobs, A. von Stechow, W. Sternefeld, and T. Venneman, 506–569. New York: Walter de Gruyter.

Cinque, G. 1999. *Adverbs and Functional Heads: A Cross-Linguistic Perspective*. Oxford: Oxford University Press.

Collins, C. 2002. Eliminating labels. In *Derivation and Explanation in the Minimalist Program*, edited by S. D. Epstein, and T. D. Seely, 42–64. Malden: Blackwell.

Collins, C. 2017. Merge(X,Y) = {X,Y}. In *Labels and Roots*, edited by L. S. Bauke and A. Blümel, 47–68. Berlin: Mouton de Gruyter.

Corbett, G. G. 1991. *Gender*. Cambridge: Cambridge University Press.

van Craenenbroeck, J., and J. Merchant. 2013. Ellipsis phenomena. In *The Cambridge Handbook of Generative Syntax*, edited by M. den Dikken, 701–745. Cambridge: Cambridge University Press.

D'Alessandro, R. 2015. Null subjects. In *Contemporary Linguistic Parameters*, edited by A. Fábregas, J. Mateu, and M. T. Putnam, 201–226. London: Bloomsbury Press.

den Dikken, M., and A. Lahne. 2013. The locality of syntactic dependencies. In *The Cambridge Handbook of Generative Syntax*, edited by M. den Dikken, 655–698. Cambridge: Cambridge University Press.

Dougherty, R. C. 1973. A survey of linguistic methods and arguments. *Foundations of Language* 10: 432–490.

Embick, D. 2015. *The Morpheme: A Theoretical Introduction*. Berlin: Mouton deGruyter.

Embick, D., and A. Marantz. 2008. Architecture and Blocking. *Linguistic Inquiry* 29: 1–53.

Embick, D., and R. Noyer. 2007. Distributed Morphology and the syntax-morphology interface. In *The Oxford Handbook of Linguistic Interfaces*, edited by G. Ramchand, and C. Reiss, 289–324. Oxford: Oxford University Press.

Fitch, W. T. 2010. *The Evolution of Language*. Cambridge: Cambridge University Press.

Fodor, J. 1983. *The Modularity of Mind*. Cambridge: MIT Press.

Fodor, J. 2000. *The Mind Doesn't Work That Way*. Cambridge: MIT Press.

Freidin, R. 2012. A brief history of generative grammar. In *The Routledge Handbook of the Philosophy of Language*, edited by D. Fara Graf and G. Russell, 895–916. London: Routledge.

Freidin, R., and H. Lasnik. 2011. Some roots of minimalism. In *The Oxford Handbook of Linguistic Minimalism*, edited by C. Boeckx, 1–26. Oxford: Oxford University Press.

Freidin, R., and J-R. Vergnaud. 2001. Exquisite connections: Some remarks on the evolution of linguistic theory. *Lingua* 111: 128–172.

Gallego, Á. J. 2012. Introduction: A framework of phases for linguistic theory. In *Phases: Developing the Framework*, edited by Á. J. Gallego, 9–44. Berlin: Mouton de Gruyter.

Gould, S. J. 2002. *The Structure of Evolutionary Theory*. Cambridge, MA: Harvard University Press.

Grimstad, M. Berg, B. Ramsevik Riksem, T. Lohndal, and T. A. Åfarli. 2018. Lexicalist vs. exoskeletal approaches to language mixing. *The Linguistic Review* 35: 187–218.

Haegeman, L. 1994. *Introduction to Government and Binding Theory*. Oxford: Blackwell.

Hankamer, J. 1973. Unacceptable ambiguity. *Linguistic Inquiry* 4: 17–68.

Harris, Z. 1951. *Methods in Structural Linguistics*. Chicago: University of Chicago Press.

Haspelmath, M. 2006. Against Markedness (And What to Replace It With). *Journal of Linguistics* 42: 25–70.

Haspelmath, M. 2008. Parametric versus functional explanations of syntactic universals. In *The Limits of Syntactic Variation*, edited by Theresa Biberauer, 75–107. Amsterdam: John Benjamins.

Haugen, E. 1953. *The Norwegian Language in America*. Philadelphia: University of Philadelphia Press.

Hauser, M. D., N. Chomsky, and W. T. Fitch. 2002. The Faculty of Language: What Is It, Who Has It, and How Did it Evolve? *Science* 298: 1569–1579.

Hornstein, N. 2009. *A Theory of Syntax*. Cambridge: Cambridge University Press.

Hornstein, N. 2013. Three Grades of Grammatical Involvement: Syntax from a Minimalist Perspective. *Mind & Language* 28: 392–420.

Hornstein, N., J. Nunes, and K. K. Grohmann. 2005. *Understanding Minimalism*. Cambridge: Cambridge University Press.

Jaeggli, O., and N. Hyams. 1988. Morphological uniformity and the setting of the null subject parameter. In Proceedings of NELS 18, edited by J. Blevins, and J. Carter, 238–253. Amherst: GLSA, University of Massachusetts, Amherst.

Judy, T., and J. Rothman. 2010. From a superset ot a subset grammar and the semantic compensation hypothesis: subject pronoun and anaphora resolution evidence in L2 English. In *BUCLD 34: Proceedings of the 34th annual Boston University Conference on Language Development*, edited by K. Franich, K. M. Iserman, and L. L. Keil, 197–208. Somerville, MA: Cascadilla Press.

Kayne, R. S. 1980. Extensions of binding and case-marking. *Linguistic Inquiry* 11: 75–96.

Koizumi, M. 1995. *Phrase structure in minimalist syntax*. Doctoral dissertation, MIT.

Kramer, R. 2015. *The Morphosyntax of Gender*. Oxford: Oxford University Press.

Kramer, R. 2016. The location of gender features in the syntax. *Language and Linguistics Compass* 10: 661–677.

Lakatos, I. 1968. Criticism and the methodology of scientific research programmes. *Proceedings of the Aristotelian Society* 69: 149–186.

Lakatos, I. 1970. Falsifications and the methodology of scientific research programs. In *Criticism and the Growth of Knowledge*, edited by Imre Lakatos and Alan Musgrave, 91–195. Cambridge: Cambridge University Press.

Lakoff, G. 1970. Global rules. *Language* 46: 627–639.

Lasnik, H. 1981. Restricting the theory of transformations. In *Explanation in Linguistics*, edited by N. Hornstein, and D. Lightfoot, 152–173. London: Longmans.

Lasnik, H. 1999. *Minimalist Analysis*. Malden: Blackwell.

Lasnik, H. 2000. *Syntactic Structures Revisited: Contemporary Lectures on Classic Transformational Theory*. Cambridge: MIT Press.

Lasnik, H. 2005. Grammar, levels, and biology. In *The Cambridge Companion to Chomsky*, edited by J. McGilvray, 60–83. Cambridge: Cambridge University Press.

Lasnik, H. 2008. On the Development of Case Theory: Triumphs and Challenges. In *Foundational Issues in Linguistic Theory*, edited by C. Otero, R. Freidin, and M-L. Zubizarreta, 17-41. Cambridge: MIT Press.

Lasnik, H., and T. Lohndal. 2010. Government-Binding/Principles & Parameters theory. *Wiley Interdisciplinary Reviews: Cognitive Science* 1: 40–50.

Lasnik, H., and T. Lohndal. 2013. Brief overview of the history of generative grammar. In *The Cambridge Handbook of Generative Syntax*, edited by M. den Dikken, 26–60. Cambridge: Cambridge University Press.

Lasnik, H., and M. Saito. 1991. On the subject of infinitives. In *Papers from the 27th Regional Meeting of the Chicago Linguistic Society*, edited by L. M. Dobrin, L. Nichols, and R. M. Rodriguez, 324–343. Chicago, IL: Chicago Linguistic Society.

Lasnik, H., and J. Uriagereka. 2005. *A Course in Minimalist Syntax*. Malden: Blackwell.

Lohndal, T. 2013. Generative grammar and language mixing. *Theoretical Linguistics* 39: 215–224.

Lohndal, T. 2014. *Phrase Structure and Argument Structure: A Case Study of the Syntax-Semantics Interface*. Oxford: Oxford University Press.

Lohndal, T. To appear. The exoskeletal model. In *The Cambridge Handbook of Distributed Morphology*, edited by A. Alexiadou, R. Kramer, A. Marantz, and I. *Oltra-Massuet. Cambridge: Cambridge University Press.*

Lohndal, T., and J. Uriagereka. 2014. Principles and Parameters/Minimalism. In *Routledge Handbook of Syntax*, edited by A. Carnie, Y. Sato, and D. Siddiqi, 509–525. London: Routledge.

Lohndal, T., and J. Uriagereka. 2017. Third-factor explanations and Universal Grammar. In *The Oxford Handbook of Universal Grammar*, edited by I. Roberts, 114–128. Oxford: Oxford University Press.

Marantz, A. 1997. No escape from syntax: Don't try morphological analysis in the privacy of your own lexicon. *University of Pennsylvania Working Papers in Linguistics* 4: 201–225.

Martin, R., and J. Uriagereka. 2000. Introduction: Some Possible Foundations of the Minimalist Program. In *Step by Step: Essays on Minimalist Syntax in Honor of Howard Lasnik*, edited by R. Martin, D. Michaels, and J. Uriagereka, 1–29. Cambridge, MA: MIT Press.

Newmeyer, F. J. 2005. *Possible and Probable Languages*. Oxford: Oxford University Press.

Perlmutter, D. M. 1971. *Deep and surface structure constraints in syntax*. New York: Holt, Rinehart & Winston.

Peters, S., and R. W. Ritchie. 1973. On the generative power of transformational grammars. *Information Sciences* 6: 49–83.

Polinsky, M. 2018. *Heritage Languages and Their Speakers*. Cambridge: Cambridge University Press.

Polinsky, Maria, and Gregory Scontras. 2020. Understanding heritage languages. *Bilingualism: Language and Cognition* 23: 4–20.

Postal, P. M. 1974. *On Raising*. Cambridge: MIT Press.

Ramchand, G., and P. Svenonius. 2014. Deriving the functional hierarchy. *Language Sciences* 46: 152–174.

Rizzi, L. 1982. *Issues in Italian Syntax*. Dordrecht: Foris.

Rizzi, L. 1997. The fine structure of the left periphery. In *Elements of Grammar*, edited by L. Haegeman, 281–337. Dordrecht: Kluwer.

Roberts, I. 2007. *Diachronic Syntax*. Oxford: Oxford University Press.

Ross, J. R. 1967. *Constraints on variables in syntax*. Doctoral dissertation, MIT.
[Published as *Infinite Syntax!* Norwood, N.J.: Ablex, 1986.]

Ross J. R. 1969. Guess who? In *Papers from the Fifth Regional Meeting of the Chicago Linguistics Society* edited by R. I. Binnick A. Davison G. M. Green and J. L. Morgan 252–639. Chicago Linguistics Society University of Chicago

Rothman, J. 2009a. Pragmatic deficits with syntactic consequences? L2 pronominal subjects and the syntax-pragmatics interface. *Journal of Pragmatics* 41: 951–973.

Rothman, J. 2009b. Understanding the nature and outcomes of early bilingualism: Romance languages as heritage languages. *International Journal of Bilingualism* 13: 155–163.

Rothman, J., and M. Iverson. 2007. Input Type and Parameter Resetting: Is Naturalistic Input Necessary? *International Review of Applied Linguistics* 45: 285–319.

Samuels, B. 2012. *Phonological Architecture: A Biolinguistic Perspectice*. Oxford: Oxford University Press.

Shlonsky, U. 2010. The cartographic enterprise in syntax. *Language and Linguistics Compass* 4: 417–429.

Smith, N., and N. Allott. 2016. *Chomsky – Ideas and Ideals*. Third Edition. Cambridge: Cambridge University Press.

Stowell, T. 1981. *Origins of phrase structure*. Doctoral dissertation, MIT.

Taraldsen, K. T. 1980. *On the nominative island condition, vacuous application and the that-trace filter*. Bloomington: Indiana University Linguistics Circle.

Uriagereka, J. 1998. *On government*. Doctoral dissertation, University of Connecticut.

Uriagereka, J. 2008. *Syntactic Anchors*. Cambridge: Cambridge University Press.

Uriagereka, J. 2012. *Spell-Out and the Minimalist Program*. Oxford: Oxford University Press.

Vergnaud, J-R. 1977. Letter to Noam Chomsky and Howard Lasnik on "Filters and Control," April 17, 1977. *Printed in Foundational Issues in Linguistic Theory, 2008*, edited by C. Otero, R. Freidin, and M-L. Zubizarreta, 4–15. Cambridge: MIT Press.

Williams, E. 2007. Dumping lexicalism. In *The Oxford Handbook of Linguistic Interfaces*, edited by G. Ramchand, and C. Reiss, 353–382. Oxford: Oxford University Press.

Wiltschko, M. 2014. *The Universal Structure of Categories: Towards a Formal Typology*. Cambridge: Cambridge University Press.

4

The Enduring Discoveries of Generative Syntax

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4.1 Introduction

We suspect that those interested in the enduring discoveries of generative syntax wish to read about empirically supported assertions about natural language syntax advanced by generative linguists (discoveries) that are currently not disproven and that are still routinely mentioned in the generative syntax literature, usually as a diagnostic tool (enduring). Acting on this suspicion, our discussion in this chapter is restricted to assertions that fit this description. Because constraints on space require us to be selective, and in order to maintain thematic alignment with other chapters in this volume, we limit our presentation to those enduring discoveries that we consider to be indisputably generative in character, insofar as they are a natural and conspicuous product of the research methodology engendered by Chomsky's philosophical commitments and his general vision for linguistic research.[1] We begin by discussing how the two main goals of generative research, which were cemented in Chomsky's earliest writings, yield a practical research methodology that allows for the rapid accumulation of new linguistic data and knowledge; a methodology that early adopters exploited to make many of the field's enduring discoveries (Section 4.2). We then discuss how, by introducing the linguistic community to generativism via his transformational theory, Chomsky fixed early research attention on nonlocal dependencies, about which many of the field's enduring discoveries are concerned (Section 4.3). Section 4.3.1 discusses the enduring discoveries made about the hierarchical syntactic structures on which nonlocal dependencies are instantiated, Section 4.3.2 reflects on the variety of nonlocal dependencies that generative research has uncovered, and Section 4.3.3 focuses on so-called *gaps* or *empty categories*, which frequently feature as members in nonlocal dependencies. We provide concluding remarks in Section 4.4.

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4.2 Shaping the Research Methodology of Generative Linguistics

It is universally accepted that the progress made by generative linguists since the late 1950s represents a significant leap in our understanding of natural language syntax. The powerful methodology wielded by generative linguists played – and continues to play – a hugely important role in this rapid advancement. In this section, we describe how the core principles of generative linguistics, which were outlined by Chomsky in the 1950s and 1960s, yielded a research methodology whose core features guarantee quick and fruitful syntactic research.

The founding dictum of generative linguistics is that linguists should study grammars, where a grammar of a particular language L is understood as a set of rules for generating the sentences that constitute L (Chomsky 1955 et seq.). From the late 1950s onward, Chomskyan generative grammar has also adopted a rationalist conception of language (Chomsky 1958, 1959), according to which "a grammar of a particular language must be supplemented by a *universal grammar* [our emphasis] that accommodates the creative aspect of language use and expresses the deep-seated regularities which, being universal, are omitted from the grammar itself" (Chomsky 1965, 6). This engenders a linguistic research program with two main goals: I. to specify the rules that generate all and only the grammatical sentences in a given language L (we return to the concept of *grammaticality* momentarily), and II. to determine which of these rules belong to the universal grammar and which are specific to L.

These two goals are directly reflected in the research methodology employed by generative linguists from the 1950s until today. The first goal is reflected in the choice of data-type used for generative linguistic research, while the second is reflected in the methodological outlook adopted by generative researchers.

To accomplish goal I., a linguist will (ideally): (i) hypothesize a grammar for L and then (ii) test to see if it correctly generates all and only the grammatical sentences in L. To successfully carry out this test, a linguist must know beforehand the grammatical status of sentences through an independent test to avoid introducing circularity into the methodology described above. This independent test comes from *acceptability judgments*. Acceptability judgments are reports provided by a native speaker of their spontaneous reaction concerning whether a particular string of words (with an intended interpretation) is a possible sentence of their language. Generative linguistics has used acceptability judgments as its primary data source since its inception (Chomsky 1955, 1957), treating these judgments as a valid and valuable source of information about the grammaticality of a sentence. In other words, generative linguistics has always assumed that the reaction triggered by exposure to a candidate sentence of one's native language can help determine whether the sentence can or cannot be generated by that language's grammar.[2] In addition to this tacit acceptance of acceptability judgments as a valid data-source, *Aspects of the theory of syntax* (1965), Chomsky's most cited book on linguistics, explicitly defended their use, arguing that no adequate alternative method of probing linguistic competence was available (at the time) or would likely be discovered, and that, on the off-chance that an alternative method was developed, acceptability judgments will still be required as a benchmark against which to test the alternative method's efficacy (p. 18–21). Chomsky therefore highlights that acceptability judgments are the most easily obtained source of ungrammatical sentences, which

are indispensable for conducting the everyday task of generative research, namely developing accurate characterizations of grammars.[3]

Accomplishing the second main goal of generative linguistic research has been regularly delayed by Chomsky's periodic refinement or revision of his conception of the universal grammar and its relation to language-specific grammars (Chomsky 1970, 1977, 1981, 1986b, 1995). Despite periodic conceptual changes, the methodological outlook used for pursuing this goal has remained constant. One aspect of this outlook is the adoption of a working method in which productive patterns observed in one language are presumed to be present in all languages until empirical evidence proves otherwise. Because discovering the properties of the universal grammar is more pressing than discovering the rules of the ancillary language-specific grammar from a rationalist perspective such as Chomsky's (as the universal grammar is innate whereas the language-specific grammar is learned), another aspect of this outlook is its focus on linguistic regularities, or "core language" (Chomsky 1986a, 147).

In sum, the theoretical commitments emplaced by Chomsky in the late 1950s and early 1960s engendered a research methodology in which informally collected acceptability judgments are used to make generalizations over linguistic regularities. Considering that acceptability judgments are reliable, relatively unequivocal (see the references in endnote 3), and are quickly obtained (especially if a linguist is collecting judgments from herself and/or a small group of consultants), and that the rationalist principles underpinning the generative paradigm has given linguists warrant to make universal claims from studying one language that they know well (usually their native tongue), it is unsurprising that this methodology yields new data, generalizations, and analyses at an extremely rapid rate. Equally, it is unsurprising that its initial application in the early days of generativist syntax to what was then an uncharted empirical landscape of syntactic regularities resulted in most of the profound – and therefore the most enduring – discoveries of generative syntax.

4.3 Generative Syntax Through the Lens of Nonlocal Dependencies

Although generative linguistics is predominantly a syntax-focused program (see Jackendoff 2002 for criticism of this fact), the methodology described in the previous section is intended for use in all linguistic subfields (see Chomsky and Halle 1968 for a famous application of the methodology to phonology). Its enduring association with syntactic research stems from the fact that Chomsky first employed the methodology to study the regularities of English syntax in *Syntactic Structures* (1957). In addition, *Syntactic Structures* also set the research agenda for precisely which syntactic regularities linguists would focus on in the early period (the 1960s and 1970s) of generative theorizing. From a broad, theory-neutral perspective, the regularities in question can each be described as instantiating a *nonlocal dependency*. One example of a nonlocal dependency is the relationship that obtains between *every Englishman* and *his* in (1): the specification for *his* depends on the specification for *every Englishman* (i.e. Gerald takes pride in Gerald's garden, Norman takes pride in Norman's garden, etc.), even though these phrases are separated by the string of words *takes pride in*.

(1) **Every Englishman** takes pride in **his** garden.

This concrete notion of a nonlocal dependency can be extended to include a slightly more abstract case, such as the dependency into which the nominal expression *the cake* enters in (3). In (2), this expression occupies a position immediately following the verb. Because this position is the designated object position in English, *the cake* is understood as the sentence's object, i.e. the thing being eaten. In (3), however, *the cake* is still understood as the object of the sentence, despite being separated from the position immediately following the verb by two words (namely, *was* and *eaten*). In this configuration, one may characterize *the cake* as entering into a *nonlocal dependency* with the position immediately following the verb, which is represented by the symbol "Δ" in (3) and is known as *the gap* (or an *empty category*).

(2) Ashley ate the cake.
(3) **The cake** was eaten Δ by Ashley.

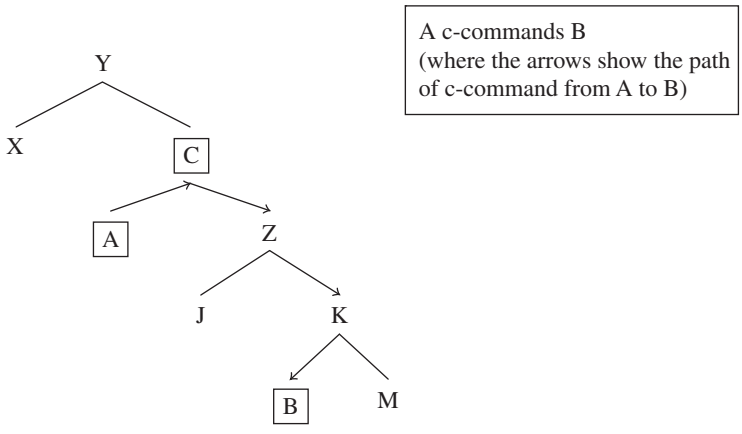
Influenced by ideas developed by Harris (1952, 1957), Chomsky in *Syntactic Structures* (1957) introduced the idea that certain sentences are derived from other sentences via rewrite rules over *phrase markers* (a special type of derivation tree whose termini are adorned with the atoms of syntactic analysis, namely words and morphemes), which he called *transformations*. One such transformation is the passive transformation, which converts the phrase marker for an active sentence such as (2) into its passive counterpart in (3). Although Chomsky did not originally view the output of a transformation as instantiating a nonlocal dependency,[4] the way in which his transformational analysis focused generative linguists' attention on nonlocal dependencies from the outset of the generativist enterprise is clear, as transformations suggest that some nonlocal connection – in this case, a derivational history – obtains between the two positions of *the cake* in (2) and (3). This early focus on nonlocal dependencies and the constraints on establishing them produced many of the early enduring discoveries of generative syntax.

In the remainder of this section, which constitutes the main body of our overview, we first outline some of the enduring discoveries made about the syntactic structures that serve as the scaffolding for nonlocal dependencies (Section 4.3.1), before turning our attention to enduring discoveries made about nonlocal dependencies themselves (Section 4.3.2). It will become clear from the discussions in these sections that natural language contains many *gaps* (also known as *empty categories*): Section 4.3.3 discusses the variety of gaps that generative linguists have uncovered.

4.3.1 Nonlocal Dependencies and Hierarchical Structure

The discovery that the establishment of a nonlocal dependency rests on hierarchical relations between words and phrases rather than on linear relations represents a watershed moment for generative syntax. This discovery was first documented by Klima (1964), who introduced the notion of *in-construction-with* (p. 297), whose converse was rebranded as *c-command* by Reinhart (1976). C-command is defined over nodes in a phrase marker. According to Reinhart's definition (p. 32), a node A c-commands a node B if and only if the first non-unary node that dominates A (call it C) also dominates B (see (4)). (Aside from A, B, and C, the labels decorating the nodes in (4) and (6) are arbitrarily assigned.)

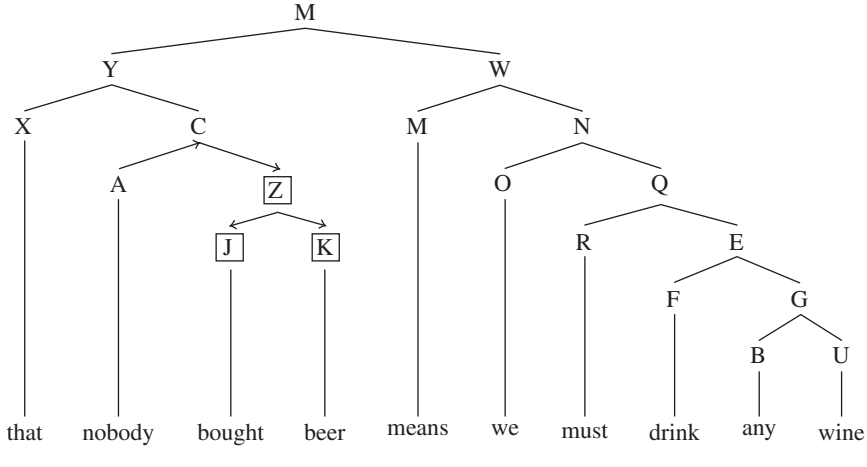
(4)



The fact that nonlocal dependencies rest on c-command is illustrated in the following sentences. *Any* in (5a) is a negative polarity item (NPI), whose use must be "licensed" by it entering into a dependency relation with a negative item such as *nobody* (in (5b), *any* is not permitted because *nobody* is absent; Klima 1964). Although it might seem from comparing (5a) and (5c) that *nobody* must merely linearly precede *any* for a dependency to be established between them, (5d) shows that an appeal to linearity alone is insufficient, as *nobody* linearly precedes *any* yet the sentence is unacceptable. The crucial insight here is that *nobody* also c-commands *any* in (5a) (transposed onto (4), *nobody* occupies A's position and *any* occupies B's position), whereas *nobody* does not c-command *any* in (5d), as (6) shows. This insight not only refined ideas about syntactic dependencies, but also conclusively demonstrates that natural language syntax is sensitive to hierarchical structure: it is a two-dimensional phenomenon. Thus, the discovery of c-command underscores the notion, which is implied in Chomsky's (1957) pioneering use of phrase markers, that syntactic relations between words/morphemes are predominantly (and perhaps exclusively; see Kayne 1994) hierarchical in nature, and that linear order is, perhaps counterintuitively, largely irrelevant to natural language syntax.

(5) a. **Nobody** thinks that Harriet wants **any** wine.
b. * Somebody thinks that Harriet wants **any** wine.[5]
c. * **Any wine** is wanted by **nobody**.
d. * That **nobody** bought beer means we must drink **any** wine.

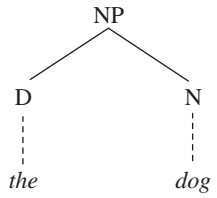
(6)



A c-commands each boxed node, which does not include B. Therefore, a non-local dependency between *nobody* and *any* cannot be established.

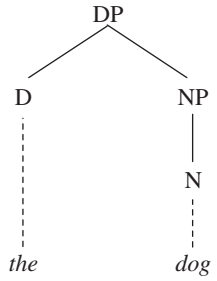
Our understanding of the hierarchical structure on which nonlocal dependencies are instantiated has undergone substantial refinement since Chomsky's (1957) pioneering use of phrase marker diagrams. From *Syntactic Structures* until the mid-1970s, words from lexical categories (e.g. nouns and verbs) and functional categories (e.g. articles such as *the* and auxiliary verbs) were treated dissimilarly with respect to syntactic structure. Lexical words were usually analyzed as heads of syntactic phrases (where a *head* of a phrase determines the phrase's category), whereas functional words were not. To provide an example, the noun (N) *dog* in (7) is the head of the noun phrase (NP), but the determiner (D) *the* is not the head of a determiner phrase. Instead, it is contained in the noun phrase.

(7)



Building on results obtained from the mid-1970s through to the mid-1980s (in particular, Emonds 1976, Jackendoff 1977, Fukui 1986, Speas 1986, and Abney 1987), Chomsky's (1986b) *Generalized X′-theory* abandoned the notion that lexical and functional words are structurally distinct. Instead, functional words behave just like lexical ones: they are heads of syntactic phrases (a determiner will 'project' a *determiner phrase* (DP), for instance (8)).[6]

(8)

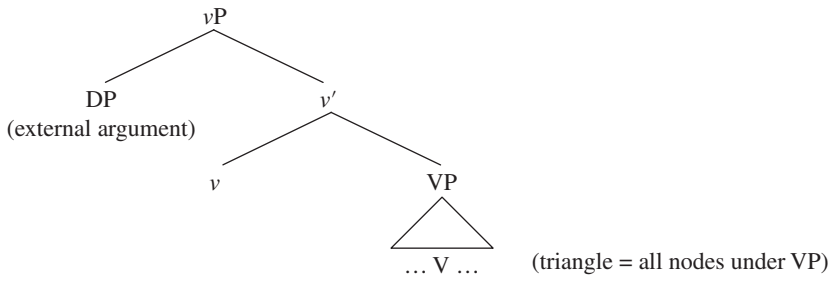


The distinction between lexical and functional items has a long tradition in linguistics. Consequently, the discovery that lexical and functional words are structurally equivalent (insofar as both project phrases) has endured because it eliminated a potential source for this distinction and therefore stimulated much research into precisely where, if not in terms of projecting phrases, the difference between lexical and functional items lies. Grimshaw (2000 [1991]) discovered that the crucial difference can be found in the respective ordering of lexical and functional phrases: lexical phrases are always dominated by functional ones. Moreover, there is a constrained pairing between lexical and functional phrases, with functional phrases acting as the *extended*

projections of the lexical phrases they dominate. For instance, the extended projections of lexical N are the projections of functional D, and these share the same categorial features with N (e.g. nominal).

Grimshaw's work in turn stimulated much research into the precise make-up of various extended projections. Certain conclusions reached in this subfield can already be viewed as "enduring discoveries," based on the weight of evidence marshalled to support them and for their utility as diagnostics of other syntactic properties. An instructive example comes from how verbs project syntactic structure. Researchers recognized that, instead of having functional projections related to tense and aspect as the immediate extended projections of V (as in Grimshaw's original system), V is immediately dominated by (at least) one functional projection that relates to the internal thematic/eventive meaning of V. The head of this projection, which is referred to as "*v*" by Chomsky (1995), is broadly identified as the syntax reflex of agentivity or causation, as it selects the external argument (i.e. the agent) of an event (Larson 1988; Hale and Keyser 1991, 1993; Krazter 1994; Chomsky 1995, 2000) (9).

(9)



Support for the existence of *v* comes from the fact that its presence explains two independent enduring discoveries. The first concerns the discovery from Perlmutter (1978) that two classes of intransitive verbs – namely, unergative and unaccusative verbs – can each be associated with different syntactic phrase markers. Despite their surface similarities, unergatives have an underlying subject while unaccusatives have an underlying object. A natural structural explanation for this distinction is that unaccusative verbs have no *v*P projection (though see Alexiadou, Anagnostopoulou, and Everaert 2004). The second enduring discovery comes from Burzio (1981), who observed that a verb can assign a thematic role (e.g. the agent, experiencer, source, etc., of an event) to its subject if and only if its object can receive accusative case. This is *Burzio's generalization*. If the functional head *v* is responsible for introducing the subject **and** assigning accusative Case to object DPs, then if *v* is missing, then Burzio's generalization is explained.

In summary, generative research has underscored the importance of syntactic hierarchy in encoding traditional linguistic distinctions (e.g. *lexical* versus *functional*), encoding compositional meaning (e.g. agentivity), and establishing dependencies between words and/or phrases.

4.3.2 A Typology of Nonlocal Dependencies

While generative linguists found a universal constraint on nonlocal dependencies in c-command (see 4.3.1), other constraints that were unearthed – and which are enduring discoveries in their own right – were observed to apply to some nonlocal

dependencies but not others. It was quickly demonstrated that, for any nonlocal dependency D, the syntactic type of the elements involved in the dependency, whether the dependency includes a gap or not (recall (1) versus (3)), and the syntactic position occupied by the top member of the dependency can each determine what constraints are emplaced on successfully establishing D in the first place.

For instance, dependencies between syntactic heads of phrases (e.g. (10)) are more constrained than dependencies between syntactic phrases themselves, as the former can only be established across a very short structural distance (two structurally consecutive syntactic heads; Travis 1984), whereas certain dependencies between syntactic phrases can be unbounded. With regards to dependencies between phrases, those involving gaps as tail members typically cannot be established if the gap is contained in one of a handful of distinguished phrases known as *islands* (Ross 1967), whereas those without gaps are typically untroubled by islands (compare (11) and (12), with an "adjunct island" headed by *because*). Therefore, the status of a dependency's tail also determines across what distance the dependency can be established.

(10) **Will** Polly Δ be attending the party?
(11) **Every auntie** thought that baby Bobby smiled [$_{\text{ISLAND}}$ because **she** had just arrived].
(12) * I know **who** baby Bobby smiled [$_{\text{ISLAND}}$ because Δ had just arrived].

When there are no syntactic islands present in a sentence, it appears at first glance that the distance across which a dependency with a phrasal tail gap can be established is unrestricted. In the sentences in (13), for instance, the apparent tops and tails of each dependency occupy different clauses, and the dependencies themselves extend across multiple clausal boundaries (which are denoted by C1, C2, and C3).

(13) a. **Xavier** seems [$_{C1}$ to appear [$_{C2}$ to want [$_{C3}$ to be hired Δ by Sue]]].
b. **Who** does Bo think [$_{C1}$ Zoë hopes [$_{C2}$ Jo believes [$_{C3}$ that Sue hired Δ]]]?

Another enduring result of generative syntax research has been to show that, in these cases, appearances are deceptive. In reality, nonlocal dependencies of this type cannot extend across more than one finite clausal boundary.[7] Thus, the sentences in (13) actually contain multiple dependencies, none of which extend across more than one clausal boundary, as illustrated in (14). The presence of each dependency in (14a,b) – a number of which consist entirely of gaps and therefore appear as "hidden" dependencies – can be confirmed through following the generative methodology outlined in Section 4.3.1: i.e. by applying syntactic tests known to diagnose the presence of such hidden dependencies and by showing that visible versions of these dependencies are attested in other languages (Frisian: Hiemstra 1986, German and Romani: McDaniel 1989; Chamorro: Chung 1994; Irish: McCloskey 2001; among many others). In certain dialects of German, for instance, the intermediate gaps in (14b) are replaced by question words, as (15) shows.

(14) (a) **Xavier** seems [$_{C1}$ Δ_1 to appear [$_{C2}$ Δ_2 to want [$_{C3}$ Δ_3 to be hired Δ_4 by Sue]]].
(b) **Who** do you believe [$_{C1}$ Δ_1 Peter thinks [$_{C2}$ Δ_2 Sue is marrying Δ_3]]?

(15) Wen glaubst du wen Peter meint wen Susi heiratet? (Felser 2004 (10))
who believe you **who** Peter thinks **who** Susi marries
'Who do you believe Peter thinks that Susi is marrying?'

We previously mentioned that the structural position occupied by the top member of a dependency may determine the syntactic properties of that dependency. This is especially noticeable for dependencies between phrases with gaps as their tail members. In such cases, a correlation exists between the structural position occupied by the top member of the dependency – whether it occupies an *argument position* (an *A-dependency*), such as the syntactic positions reserved for subjects and objects, or a *non-argument* position (an *A′-dependency*) – and how the dependency interacts with other grammatical phenomena. If a nominal expression that refers to the same person or thing as the top member of a dependency D intervenes between the top and tail members of D, D is licit if it is an A-dependency but illicit if it is an A′-dependency (this is a *crossover effect*; Postal 1971) (compare (16a) and (16b)). A- and A′-dependencies differ in other ways, too. A′- but not A-dependencies can license the presence of *parasitic gaps* (compare (17a) and (17b), where "Δ_P" represents a parasitic gap) (Ross 1967, Engdahl 1983), and the top member of an A-dependency can also be the tail member of an A′-dependency, but not vice versa (compare (18a) and (18b)) (Chomsky 1973). Their behavior also differs with respect to *reconstruction* (May 1977, Chomsky 1977, van Riemsdijk and Williams 1981; see Barss 2001 for an overview), a pervasive linguistic phenomenon to which we return in Section 4.3.4.

(16) a. **Fiona** seems to *her* mother Δ to be a genius. [A]
(acceptable when *Fiona* and *her* are interpreted as referring to the same person)

b. * **Who** does *her* mother love Δ? [A′]
(*un*acceptable when *who* and *her* are interpreted as referring to the same person)

(17) a. **This secret file** should be burned Δ after reading {it / *Δ_P}. [A]
b. **Which secret** file did the FBI agent burn Δ after reading {it / Δ_P}? [A′]

(18)
(a) **Who** does Hans think Δ_1 was fired Δ_2 by Sue?
A′ A

(b) ***Who** is believed Δ_1 that Sue hired Δ_2?
A A′

Having uncovered this rich empirical landscape of nonlocal dependencies with tail gaps, an obvious question that arose was this: For each type of dependency with a tail gap, is there a mirror version, whereby the top is a gap and the tail is an overt item? And if so, do these mirror versions display the same properties as the originals? Thanks to

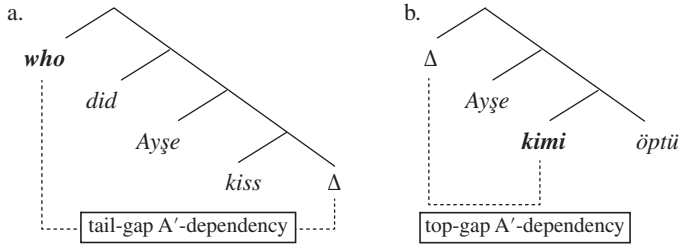
another handful of enduring discoveries, generative linguists have demonstrated that both questions must be answered with "yes." Although originally couched in the language of transformations, a "top-gap" dependency between heads was first postulated by Chomsky (1957) for English verbal inflection (19), and the universal presence of such dependencies in natural language has been confirmed by much succeeding research (see Adger, Harbour, and Watkins 2009; Harley 2013; and Harizanov and Gribanova 2018 for discussion).

(19) Polly Δ often eat-**s** raw carrots for breakfast.

In many languages, question phrases such as *who*, *why*, and *which student* do not occupy the sentence-initial position in a standard question – as in English – but instead occupy their typical position in non-question counterparts (e.g. the subject, object, or adverbial position). Such languages are known as *wh-in-situ* languages. Generative linguists discovered that question phrases in *wh*-in-situ languages instantiate top-gap A′-dependencies (see the Turkish example in (20)), in which the gap occupies a position high above the sentence, therefore allowing the question phrase, via its connection with the gap, to take logical scope over the entire sentence. The establishment of these top-gap dependencies is constrained in precisely the same manner as their tail-gap counterparts (see examples (11) and (12) and accompanying text).[8] To see this clearly, compare the simplified phrase markers in (21). Putting irrelevant differences between these languages aside, one observes that their question-formation strategies are the same, differing only in which member of the A′-dependency is pronounced (i.e. top-gap in English vs. tail-gap in Turkish).

(20) Δ Ayşe **kim-i** öp-tü?
Ayşe who-ACC kiss-PST
'Who did Ayşe kiss?'

(21)



In addition, generative linguists have also discovered that some languages, such as Adyghe (a Northwest Caucasian language; see Potsdam and Polinsky 2012), utilize top-gap A-dependencies. In (22), the subject of root clause is an unpronounced gap, yet this gap co-refers with the demonstrative pronoun *a-xe-me* "these/they" in the embedded infinitival clause.

(22) Δ [**a-xe-me** pjəsme-r a-txə-new] ø-fjež'a-ʁe-x
DEM-PL-ERG letter-ABS 3PL.ERG-write-INF 3ABS-begin-PST-3PL.ABS
'They began to write a letter.'

When neither the top nor the tail of a dependency D is a gap (and therefore both the top and the tail are overt items), in cases where the dependencies concern nominal expressions, the status of the tail often determines which constraints are emplaced on establishing D.[9] For instance, the locality conditions on establishing the dependency vary according to whether the tail member is a personal or possessive pronoun (e.g. *she*, *her*) or a reflexive or reciprocal pronoun (e.g. *herself*, *each other*). Roughly speaking, a personal or possessive pronoun P can establish a syntactic dependency with a c-commanding nominal expression N only if N does not occupy P's *binding domain* (23),[10] whereas a reflexive or reciprocal pronoun R can establish a syntactic dependency with N only if N occupies R's binding domain (24).

(23) a. **William** thinks that [$_{BD}$ Edith dislikes **him**].
b. * Edith thinks that [$_{BD}$ **William** dislikes **him**].
(BD = binding domain for *him*)

(24) a. * **William** thinks that [$_{BD}$ Edith dislikes **himself**].
b. Edith thinks that [$_{BD}$ **William** dislikes **himself**].

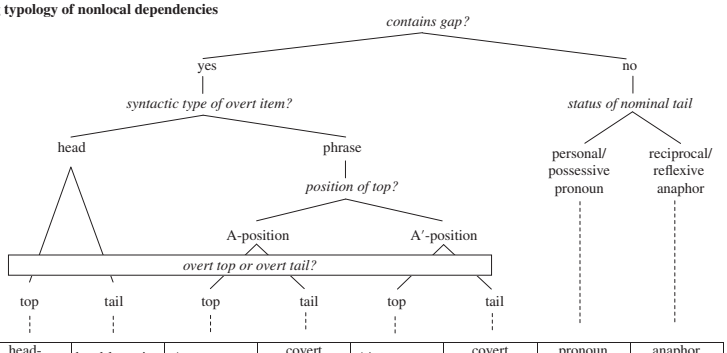
Interestingly, common and proper noun phrases, such as *the red apple* and *London*, can never be tails of non-gap dependencies, as (25) shows. In this example, the sentence is judged as unacceptable if *she* and *Virginia* refer to the same person. The sentence is only acceptable if *she* and *Virginia* refer to different people, in which case no dependency is established between the two phrases.

(25) **She** regrets that **Virginia** hurt Joseph's feelings.

When a nominal tail engages in such dependencies, it is referred to as *bound*. The three facts about nominal binding exemplified in (23) to (25) have endured because they are incredibly useful for diagnosing syntactic structure. For instance, if one wants to know the size of particular syntactic phrase P (i.e. whether it is as large as a *binding domain*), one can test to see how bound pronouns behave within P. Alternatively, if one wants to know if a particular hierarchical position A in a sentence c-commands another position B, one can see if a nonlocal dependency between two co-referring proper nouns can be established using these positions. If it cannot, then A c-commands B.

It should be clear at this juncture that one can organize the discoveries discussed so far in this subsection such that they form an emerging typology of nonlocal syntactic dependencies. This typology is presented in diagrammatic form in (26).

(26) **Emerging typology of nonlocal dependencies**



name in literature	head-movement	head-lowering	A-movement	covert A-movement	A′-movement	covert A′-movement	pronoun binding	anaphor binding
syntactic category of top	any head	any head gap	DP	DP gap	AP, CP, DP, PP, or *v*P	AP, CP, DP, PP, or *v*P gap	quantifier or referential DP	
locality restrictions	dependency must be between structurally consecutive heads		dependency cannot extend across a finite clausal boundary		dependency cannot extend across islands or a finite clausal boundary		top outside tail's *binding domain*	top and tail in tail's *binding domain*
example(s) in the main text	10	19	3, 13a, 16a, 17a	22	12, 13b, 15, 16b, 17b	20	1, 11, 23a	24b

We must emphasize here that, although the table in (26) consolidates the preceding text in a clear and instructive way, it does not attempt to provide an exhaustive typology of the nonlocal dependencies uncovered by generative linguists over the last 60 years. The main reason for this is that the position of certain types of nonlocal dependencies within this table is still debated. For instance, it remains undecided whether the phenomenon of *extraposition*, which involves phrases appearing rightward of their canonical position (compare (27a) and (27b–c)) and which was first documented by Rosenbaum (1967), involves a gap (27b) (as Ross 1967 and Baltin 1981 contend) or not (27c) (as Culicover and Rochemont 1990 and Haider 2010 argue).

(27) a. Someone **that I don't know** has left a message on your answer machine.
b. Someone Δ has left a message on your answer machine **that I don't know**.
c. **Someone** has left a message on your answer machine **that I don't know**.

This typology (or one similar to it) has endured because it represents the agreed-upon generalizations that form the bedrock for much recent generative linguistic research. This research has typically aimed to either (i) subsume a newly discovered or neglected nonlocal dependency under an established class or (ii) show that certain classes in the established typology are only superficially different, and that, at the correct level of analysis, they are indistinct.

In research that aims to fulfill (i), the discoveries that constitute (26) are used as diagnostic tools. Consider the phenomenon of *scrambling* (Ross 1967), which refers to the process that derives noncanonical word orders, typically within the same clause (compare (28a) and (28b), from Japanese).

(28) a. Mary-ga sono hon-o yonda (canonical word order)
Mary-NOM that book-ACC read
'Mary read that book.'

b. sono hon-o Mary-ga yonda (scrambled word order)
that book-ACC Mary-NOM read
'Mary read that book.'

Recall that A- and A′-dependencies behave differently with respect to crossover and parasitic gaps (recall the discussion surrounding the examples in (16) to (18)). By using these facts and others as diagnostic tools – i.e. by observing how scrambling behaves with respect to these phenomena – linguists were able to determine whether scrambling is an A- or A′-dependency. It transpires that there are actually two forms of scrambling (A-scrambling and A′-scrambling) (Fanselow 1990; Mahajan 1990; Webelhuth 1992; see Karimi 2008 for an overview), an important discovery demonstrating that the same surface syntactic pattern – namely, noncanonical word-order – can arise from distinct grammatical processes.

In attempting to reduce the typology in (26) to a more fundamental picture, research that aims to fulfil (ii) frequently tackles the question of why natural language contains the seemingly different classes of nonlocal dependencies that it does. Chomsky's linguistic research from the mid-1970s onward has reductionist tendencies in this

vein, and has been explicitly reductionist since 1995's *Minimalist Program*. A common target for this type of linguistic research is locality constraints. For instance, Chomsky (1977) famously proposed that the locality constraints on establishing an A′-dependency – namely, that an A′-dependency cannot extend across a syntactic island or two clausal boundaries – are reflections of one underlying locality constraint called *Subjacency*. According to conceptual framework behind Subjacency, certain phrases (the Tense Phrase and the Noun Phrase in English) are, by their nature, partial disruptors of A′-dependencies that extend across them. This idea has been retained in Subjacency's successor, the *Phase Theory* (Chomsky 2000, 2001a, 2001b), in which certain phrases (the Complementizer Phrase and the *v*P (as in (9)) are again considered to be inherent disruptors of nonlocal dependencies. In removing the notion of syntactic islands from syntactic theory, Subjacency and its successor Phase Theory in effect unite the locality conditions on A and A′-dependencies, with the ban on Improper Movement (see (18b)) yielding the apparent finite-clause-boundedness of A-dependencies.

4.3.3 A Typology of Gaps

When coupled with the fact that functional heads are often "empty" (see Section 4.3.1), the typology in (26) also underscores the fact that, at least according to most interpretations of fruitful generative inquiry, natural language contains many gaps. The ubiquity of gaps in natural language – not only as the tops and tails of nonlocal dependencies but also as independent items – has prompted extensive research into the precise status of gaps and whether all gaps have the same status. With regards to the former issue, generative linguists are divided as to whether gaps are linguistic items in their own right, akin to "silent" phrases, words, or morphemes, depending on the gap in question (this tradition starts with Chomsky 1973), or whether they are merely indications of the special grammatical or categorial status of the syntactic phrase in which the gap is found (this tradition took hold with Gazdar et al. 1985). With regards to the issue of whether all gaps have the same status, the picture is also unclear, with differences posited in earlier generative research being subject to reductivist reanalysis, especially within the current post-1995 *Minimalist* paradigm. However, many of differences between gaps posited in earlier research can nonetheless be classified as enduring discoveries, as few – if any – reductivist analyses of gaps enjoy universal acceptance.

Famously, different types of gaps have been implicated in explanations of the semantic and syntactic behavior of predicates that select infinitival clauses. Rosenbaum (1967) observed that, despite their superficial similarity, sentences such as (29) and (30) are inherently different in meaning. In (29), *Kate* is understood as the agent of *helping Meghan* event, but not of the *seeming to help Meghan* event (in fact, the latter event has no agent whatsoever). In (30), however, *Kate* is understood as the agent of both the *helping Meghan* and the *promising to help Meghan* event.

(29) Kate seems to help Meghan.
(30) Kate promises to help Meghan.

This difference in meaning suggests that *seem* does not assign an agentive thematic role to its subject *Kate*, whereas *promise* does. Because this is confirmed by various independent syntactic tests (see Landau 2013), Rosenbaum (1967), Postal (1974), and many researchers since them assume that this difference between *seem*- and

promise-type predicates is reflected in syntactic structure.[11] The example in (29) is analyzed as derived by a transformation called *raising* that "moves" *Kate* from the subject position in the embedded clause (i.e. immediately preceding *to*) to the subject position in the root clause (i.e. immediately preceding *seems*) (31). The gap in (31) is therefore a *trace* of the position that *Kate* occupied before raising occurs (see endnote 4).

(31) **Kate** seems $\boldsymbol{t_{Kate}}$ to help Meghan. (where t_{Kate} is the trace of *Kate*'s raising)
(32) **Kate** seems **PRO** to help Meghan. (where PRO is silent pronoun interpreted as "Kate")

By contrast, Rosenbaum treated the gap in (30) as an unpronounced nominal (later analyzed as a silent pronoun called *PRO*; see Chomsky 1981 for a thorough treatment), which enters into a nonlocal dependency with *Kate* and is understood as co-referent with her, yet is not related to *Kate* through a derivational history (32). In the linguistic jargon, Kate *controls* the interpretation of PRO.

PRO and standard, pronounced nominals show a complementary syntactic distribution. However, many languages display silent pronouns that can occupy the same positions that pronounced pronouns can, such as the subject position of a finite clause (33). To distinguish them from PROs, these silent pronouns are referred to as "little" *pro*s (Chomsky 1981). Proof that the "missing" subject in (33) is indeed instantiated syntactically by *pro* (rather than being merely pragmatically inferred) comes from the fact that it engages in a syntactic dependency with the verb for first-person singular agreement.

(33) Δ_{pro} sen-i gör-dü-**m** [Turkish]
2SG-ACC see-PST-1SG
"I saw you."

Throughout this section, we have used the symbol Δ to represent gaps, which could give the impression that all gaps are atomic, and hence devoid of internal structure. Although some gaps are indeed atomic (e.g. null simplex syntactic heads, see Section 4.3.1), generative research has shown that many are nonatomic, and therefore have internal complexity. An instructive example comes from the domain of ellipsis. *Ellipsis* is a family-resemblance term in generative linguistics, whose archetype is post-auxiliary predicate ellipsis in English. This refers to sentences in which a predicate – often a verb phrase – is missing yet inferred (34). Evidence that the missing predicate is a syntactic phrase with internal structure comes from the discovery that these silent phrases can contain the tail of a nonlocal dependency (35) (see Haïk 1987 for detailed discussion). If the missing predicate were a simple, atomic syntactic element, then no nonlocal dependency would be established in (35) and the sentence would be unacceptable, contrary to observation.

(34) David should arrive on time and Fiona should Δ, too.
(35) I know who will arrive on time and also **who** won't ~~arrive on time Δ~~.
(where strikethrough represents the silent, elliptic predicate)

Beyond ellipsis, there is evidence that gaps in certain A′-dependencies also have internal structure. This evidence comes from the phenomenon of *reconstruction*, which was mentioned briefly in Section 4.3.2. *Reconstruction* describes situations in which the top member of an A′-dependency behaves as though it occupies the tail position of its dependency. Consider the second sentence in (36), in which the reference of *her first PhD student* is dependent on the reference of *every professor* (i.e. Professor Brown remembers Olivia, Professor Black remembers Davina, etc.). Recall from (1) that *her* must be c-commanded by *every professor* for this co-variant interpretation to be possible. On the surface, *her first PhD student* is not c-commanded by *every professor* in (36). However, this phrase is engaged in an A′-dependency with a gap that **is** c-commanded by *every professor*, and is interpreted as occupying this position.

(36) a. No professor is likely to remember her very first undergraduate student.
b. But **her first PhD student,** every professor will remember Δ.

A′-dependency

Although reconstructed interpretations can arise from different sources (Lechner 1998), it is uncontested that many reconstructed interpretations come from the fact that the gap in certain A′-dependencies has internal structure, and is actually a verbatim yet silent copy of the A′-dependency's top member (37) (Chomsky 1995 [1993]). Thus, the existence of reconstructed interpretations reveals that many syntactic "gaps" are merely standard yet unpronounced syntactic phrases.

(37) … but **her first PhD student**, every professor will remember ~~her first PhD student~~.

4.3.4 Section Summary

By viewing generative syntactic research through the lens of nonlocal dependencies, we presented in this section approximately 35 enduring discoveries of generative syntax (depending on how one counts). Primarily, generative research has uncovered that (i) grammatical function is typically reflected in hierarchical structure, (ii) natural language is awash with nonlocal dependencies of various types, and (iii) there exist a variety of linguistic elements that contribute to meaning and participate in syntactic dependencies yet are not pronounced.

4.4 Conclusion

The foundation for contemporary generative syntactic research is a broad class of generalizations about natural language syntax that were (primarily) discovered between the late 1950s and the early 1980s and that (primarily) concern nonlocal syntactic dependencies and the hierarchical structure on which they are instantiated. These generalizations are "enduring" because they are cross-linguistically robust, they can be organized into typologies that encourage reductivist analysis, and they serve as useful diagnostic tools. The fact that generative syntax has uncovered such a large number of generalizations in such a short span of time (relative to the progress made in

the centuries that preceded its inception) is directly attributable to its conceptual and methodological foundations, which were established by Noam Chomsky in his earliest work on language.

Endnotes

1 Our intended readership is broad, extending beyond generative linguists. For a more comprehensive list of the enduring discoveries of generative syntax that is aimed primarily at generative linguists, see D'Alessandro (2019).

2 Generativism has never denied that acceptability judgments are influenced by many factors demonstrably unrelated to grammaticality, such as processing costs and cultural norms. The name "acceptability judgment" (as opposed to "grammaticality judgment"), which originates with Chomsky (1965), explicitly acknowledges this fact. Generative linguists aim to control for these extraneous factors in their elicitation procedures, or alternatively take these confounds into consideration when developing their analyses.

3 For most of the generativist period, acceptability judgments have been collected using an *informal* methodology that does not meet the experimental standards expected in neighboring fields such as psychology (see Schütze and Sprouse 2013, 30 for details). Although it has attracted criticism (Edelman and Christiansen 2003, Ferreira 2005, Wasow and Arnold 2005, Featherston 2007, Gibson and Fedorenko 2010, 2013; see Hill 1961 for an early critique), recent research has demonstrated that, thanks to large effect-sizes, this method of collecting judgments is as reliable as "formal" collection methods, with convergence between the two ranging between 86% to 99% (Sprouse and Almeida 2012, 2013, 2017a, 2017b; Sprouse, Schütze and Almeida 2013, Schütze 2020).

4 Viewing transformations as descriptions of nonlocal dependencies came later and indirectly, via Chomsky's adoption from Hockett (1958) of *deep* versus *surface structure* in Chomsky 1964 and via his technical innovation of *traces* in Chomsky 1973. See Chomsky 1977 for a partial subsumption of traces under silent pronouns (or, more precisely, *PRO*) and Koster 1978 for an early argument for abandoning the notion that any nonlocal dependencies are established via the application of transformational rules.

5 The asterisk symbol is used to denote that an example sentence is judged by native speakers as unacceptable. In the absence of any observable confounding factors, this judgment is viewed as evidence that the sentence in question is also ungrammatical.

6 For the sake of simplicity, the phrase marker in (8) avoids representing the X′-levels characteristic of X′-theory.

7 This is a crude description, based on a generalization that provoked Chomsky's (1977) theory of *Subjacency* (see the concluding paragraphs of Section 4.3.2). For a more contemporary perspective, in which many more "hidden" dependencies are postulated than are represented in the examples in (14) (and (18)), see the discussion following example (28) and the references provided there.

8 The idea that question phrases in *wh*-in-situ languages are tails in a top-gap A′-dependency was first advanced by Aoun, Hornstein, and Sportiche (1981). At first glance, it appears that the top-gap and tail-gap A'-dependencies that are utilized to form constituent questions across languages differ in their locality constraints, as the former appear to be establishable across island boundaries, unlike the latter (compare (i) below with (14) in the main text). Subsequent research has shown that this difference is only apparent. In island-obviating cases, the entire island (Nishigauchi 1986, Choe 1987, Pesetsky 1987) or a Q-morpheme associated with it (Cheng 1991, Hagstrom 1999, Cable 2010) is the tail of the dependency, not the question phrase contained within it.

(i) Ali [$_{\text{ISLAND}}$ **kim** gel-di diye] gülümse-di? [Turkish]
Ali who arrive-PST COMP smile-PST
'Who is it such that Ali smiled because s/he arrived?'

9 These constraints form the *Binding Theory*. See Chomsky (1981) for an influential formulation.

10 Precisely how to define a *binding domain* has been a long-standing topic of debate. For a definition based solely on hierarchical syntactic structure, see Chomsky (1981). For a definition which considers hierarchical structure and linear order (in particular, *precedence*) see Langacker (1969), Lasnik (1976), and Bruening (2014). For definitions that define binding over functional relations such as *obliqueness*, which are only partly reflected in hierarchical structure, see Pollard and Sag (1994) and Bresnan (2001).

11 This assumption is not universally upheld. For instance, offshoots of mainstream generativism such as Head Driven Phrase Structure Grammar (Sag and Pollard 1991), Lexical Functional Grammar (Bresnan 1982), and Simpler Syntax (Culicover and Jackendoff 2005) maintain that the difference in argument-structure properties between *seem*- and *promise*-type predicates is not reflected in syntactic structure. In the generative literature, this idea originates with Bach (1977).

References

Abney, S. 1987. *The English Noun Phrase in Its Sentential Aspect*. PhD diss., MIT.

Adger, D., D. Harbour, and L. Watkins. 2009. *Mirrors and Microparameters: Phrase Structure Beyond Free Word Order*. Cambridge: Cambridge University Press.

Alexiadou, A., E. Anagnostopoulou, and M. Evereart. 2004. *The Unaccusativity Puzzle: Explorations of the Syntax-Lexicon Interface*. Oxford: Oxford University Press.

Aoun, J., N. Hornstein, and D. Sportiche. 1980. "Some Aspects of Wide Scope Quantification." *Journal of Linguistic Research* 1, 69–95.

Bach, E. 1977. "Review article on Postal, *On Raising: One Rule of English Grammar and Its Theoretical Implications*." *Language* 53, 621–54. DOI: 10.2307/413179

Baltin, M. 1981. "Strict bounding." In *The Logical Problem of Language Acquisition*, edited by C. L. Baker and J. McCarthy, 257–295. Cambridge, MA: MIT Press.

Barss, A. 2001. "Syntactic Reconstruction Effects." In *The Handbook of Contemporary Syntactic Theory*, edited by M. Baltin and C. Collins, 670–696. London: Blackwell. DOI:10.1002/9780470756416.ch21.

Bresnan, J. 1982. *The Mental Representation of Grammatical Relations*. Cambridge, MA: MIT Press.

Bresnan, J. 2001. *Lexical-Functional Syntax*. Oxford: Blackwell.

Bruening, B. 2014. "Precede-and-Command Revisited." *Language* 90, 342–388. DOI: 10.1353/lan.2014.0037.

Burzio, L. 1981. *Intransitive Verbs and Italian Auxiliaries*. PhD diss., MIT.

Cable, S. 2010. *The Grammar of Q: Q-Particles, Wh-Movement and Pied-Piping*. Oxford: Oxford University Press.

Cheng, L. L.-S. 1991. *On the Typology of Wh-Questions*. PhD diss., MIT.

Choe, Jae W. 1987. "LF Movement and Pied-Piping." *Linguistic Inquiry* 18, 348–353.

Chomsky, N. 1955. *Transformational Analysis. PhD diss.*, University of Pennsylvania.

Chomsky, N. 1957. *Syntactic Structures*. The Hague: Mouton.

Chomsky, N. 1958. "Linguistics, Logic, Psychology, and Computers." In *Computer Programming and Artificial Intelligence*, edited by J. W. Carr, 429–454. Ann Arbor, MI: Michigan University College of Engineering.

Chomsky, N. 1959. "Review of Skinner (1957)." *Language* 35, 26–58. DOI: 10.2307/411334.

Chomsky, N. 1964. "Current Issues in Linguistic Theory." In *The Structure of Language*, edited by J. A. Fodor and J. J. Katz, 50–118. Englewood Cliffs, NJ: Prentice-Hall.

Chomsky, N. 1965. *Aspects of the Theory of Syntax*. Cambridge, MA: MIT Press.

Chomsky, N. 1970. "Remarks on Nominalization." In *Readings in English Transformational Grammar*, edited by R. Jacobs and P. Rosenbaum, 184–221. Waltham, MA: Blaisdell.

Chomsky, N. 1973. "Conditions on Transformations." In *A Festschrift for Morris Halle*, edited by S. R. Anderson and P. Kiparsky, 232–286. New York: Holt, Rinehart and Winston.

Chomsky, N. 1977. "On *wh*-movement." In *Formal Syntax*, edited by P. W. Culicover, T. Wasow, and A. Akmajian, 71–133. New York: Academic Press.

Chomsky, N. 1981. *Lectures on Government and Binding: The Pisa Lectures*. Dordrecht: Foris.

Chomsky, N. 1986a. *Knowledge of Language: Its Nature, Origin, and Use*. New York: Praeger.

Chomsky, N. 1986b. *Barriers*. Cambridge, MA: MIT Press.

Chomsky, N. 1993. "A Minimalist Program for Linguistic Theory." *In The View from Building 20: Essays in Linguistics in Honor of Sylvain Bromberger*, edited by K. L. Hale, and S. J. Keyser, 1–52. Cambridge, MA: MIT Press. Reprinted in Chomsky (1995a).

Chomsky, N. 1995b. *The Minimalist Program*. Cambridge, MA: MIT Press.

Chomsky, N. 2000. "Minimalist Inquiries: The framework." In *Step by Step: Essays on Minimalist Syntax in Honor of Howard Lasnik*, edited by R. Martin, D. Michaels and J. Uriagereka, 89–155. Cambridge, MA: MIT Press.

Chomsky, N. 2001a. "Derivation by Phase." In *Ken Hale: A Life in Language*, edited by M. Kenstowicz, 1–50. Cambridge, MA: MIT Press.

Chomsky, N. 2001b. "Beyond Explanatory Adequacy." *MIT Occasional Papers in Linguistics* 20, 1–28.

Chomsky, N. and M. Halle. 1968. *The Sound Pattern of English*. New York: Harper and Row.

Chung, S. 1994. "*Wh*-agreement and "Referentiality" in Chamorro." *Linguistic Inquiry* 25, 1–44.

Culicover, P. W. and M. J. Rochemont. 1990. "Extraposition and the Complement Principle." *Linguistic Inquiry* 21, 23–47.

Culicover, P. W. and R. Jackendoff. 2005. *Simpler Syntax*. Oxford: Oxford University Press.

D'Alessandro, R. 2019. "The Achievements of Generative Syntax: A time chart." *Catalan Journal of Linguistics* [Special Issue: Generative Syntax. Questions, Crossroads, and Challenges], 7–26. DOI: https://doi.org/10.5565/rev/catjl.232.

Edelman, S. and M. Christiansen. 2003. "How Seriously Should We Take Minimalist Syntax?" *Trends in Cognitive Sciences* 7, 60–61. DOI: 10.1016/s1364-6613(02)00045-1.

Emonds, J. 1976. *A Transformational Approach to English Syntax*. New York: Academic Press.

Engdahl, E. 1983. "Parasitic Gaps." *Linguistics and Philosophy* 6, 5–34. DOI: 10.1007/BF00868088.

Fanselow, G. 1990. "Scrambling as NP Movement." In *Scrambling and Barriers*, edited by G. Grewendorf and W. Sternefeld, 113–140. Amsterdam: John Benjamins. DOI: 10.1075/la.5.07fan.

Featherston, S. 2007. "Data in Generative Grammar: The Stick and the Carrot." *Theoretical Linguistics* 33, 269–318. DOI: 10.1515/TL.2007.020.

Felser, C. 2004. "*Wh*-copying, Phases, and Successive Cyclicity." *Lingua* 114, 543– 574. DOI: 10.1016/S0024-3841(03)00054-8.

Ferreira, F. 2005. "Psycholinguistics, Formal Grammars, and Cognitive Science." *The Linguistic Review* 22, 365–380. DOI: 10.1515/tlir.2005.22.2-4.365.

Fukui, N. 1986. *A Theory of Category Projection and Its Applications*. PhD diss., MIT.

Gazdar, G., E. Klein, G. K. Pullum and I. A. Sag. 1985. *Generalized Phrase Structure Grammar*. Cambridge, MA: Harvard University Press.

Gibson, E. and E. Fedorenko. 2010. "Weak Quantitative Standards in Linguistics Research." *Trends in Cognitive Sciences* 14, 233–234. DOI: 10.1016/j.tics.2010.03.005.

Gibson, E. and E. Fedorenko. 2013. "The Need for Quantitative Methods in Syntax and Semantics Research." *Language and Cognitive Processes* 28, 88–124. DOI: 10.1080/01690965.2010.515080.

Grimshaw, J. 2000. "Locality and Extended Projection." In *Lexical Specification and Insertion*, edited by P. Coopmans, M. Everaert, and J. Grimshaw, 115-133. Amsterdam: John Benjamins. DOI: 10.1075/cilt.197.07gri.

Hagstrom, P. 1998. *Decomposing Questions*. PhD diss., MIT.

Haider, H. 2010. *The Syntax of German*. Cambridge: Cambridge University Press.

Haïk, I. 1987. "Bound VPs that Need to Be." *Linguistics and Philosophy* 10, 503–530. DOI: 10.1007/BF00628068.

Hale, K. and S. J. Keyser. 1991. *On the Syntax of Argument Structure*. *Lexicon Project Working Papers 34*, Center for Cognitive Science, MIT.

Hale, K. and S. J. Keyser. 1993. "On Argument Structure and the Lexical Expression of Syntactic Relations." In *The View from Building 20: Essays in Linguistics in Honor of Sylvain Bromberger*, edited by K. Hale and S. J. Keyser, 59–109. Cambridge, MA: MIT Press.

Harizanov, B. and V. Gribanova. 2019. "Whither head movement?" *Natural Language and Linguistic Theory* 37, 461–522. DOI: 10.1007/s11049-018-9420-5.

Harley, H. 2013. "Diagnosing Head Movement." In *Diagnosing Syntax*, edited by L. Cheng and N. Corver, 112–119. Oxford: Oxford University Press. DOI: 10.1093/acprof:oso/9780199602490.003.0006.

Harris, Z. S. 1952. "Discourse Analysis." *Language* 28, 1–30. DOI: 10.2307/409987.

Harris, Z. S. 1957. "Co-occurrence and Transformation in Linguistic Structure." *Language* 33, 283–340. DOI: 10.2307/41115.

Hiemstra, I. 1986. "Some Aspects of *Wh*-questions in Frisian." *Nowele* 8, 97–110. DOI: 10.1075/nowele.8.06hie.

Hill, A. A. 1961. "Grammaticality." *Word* 17, 1–10. DOI: 10.1080/00437956.1961.11659742.

Hockett, C. F. 1958. *A Course in Modern Linguistics*. New York: The Macmillan Company.

Jackendoff, R. 1977. *X′-Syntax: A Study of Phrase Structure*. Cambridge, MA: MIT Press

Jackendoff, R. 2002. *Foundations of Language: Brain, Meaning, Grammar, Evolution*. Oxford: Oxford University Press. DOI: 10.1093/acprof:oso/9780198270126.001.0001.

Karimi, S. 2008. "Scrambling." *Language and Linguistics Compass* 2/6, 1271–1293. DOI: 10.1111/j.1749-818X.2008.00095.x.

Klima, E. 1964. "Negation in English." In *The Structure of Language*, edited by J. A. Fodor and J. J. Katz, 246–323. Englewood Cliffs, NJ: Prentice-Hall.

Koster, J. 1978. "Conditions, Empty Nodes, *and Markedness." Linguistic Inquiry* 9, 551– 593.

Landau, I. 2013. *Control in Generative Grammar: A Research Companion*. Cambridge: Cambridge University Press.

Langacker, R. 1969. "On Pronominalization and the Chain of Command." In *Modern Studies in English: Readings in Transformational Grammar*, edited by D. Reibel and S. Schane, 160–186. Englewood Cliffs, NJ: Prentice-Hall.

Larson, R. 1988. "On the Double Object Construction." *Linguistic Inquiry* 19, 335–392.

Lasnik, H. 1976. "Remarks on Coreference." *Linguistic Analysis* 2, 1–22. DOI: 10.1007/978-94-009-2542-7_4.

Lechner, W. 1998. "Two Kinds of Reconstruction." *Studia Linguistica* 52, 276–310. DOI: 10.1111/1467-9582.00037.

Mahajan, A. 1990. *The A/A′ Distinction and Movement Theory*. PhD diss., MIT.

May, R. 1977. *The Grammar of Quantification*. PhD diss., MIT.

McCloskey, J. 2001. "The Morphosyntax of WH-extraction in Irish." *Journal of Linguistics* 37, 67–100. DOI: 10.1017/S0022226701008775.

McDaniel, D. 1989. "Partial and Multiple *Wh*-movement." *Natural Language and Linguistic Theory* 7, 565–604. DOI: 10.1007/BF00205158.

Nishigauchi, T. 1986. *Quantification in Syntax*. PhD diss., University of Massachusetts Amherst.

Perlmutter, D. 1978. "Impersonal Passives and the Unaccusative Hypothesis." In *Proceedings of the Fourth Annual Meeting of the Berkeley Linguistic Society*, edited by J. Jaeger et al., 157–189. Berkeley, CA: University of California, Berkeley.

Pesetsky, D. 1987. "*Wh*-in-situ: Movement and Unselective Binding." In *The Representation of (In)definiteness*, edited by E. Reuland and A. ter Meulen, 98–129. Cambridge, MA: MIT Press.

Pollard, C. J. and I. A. Sag. 1994. *Head-driven Phrase Structure Grammar*. Chicago, IL: University of Chicago Press.

Postal, P. 1971. *Cross-over Phenomena*. New York: Holt, Rinehart and Winston.

Postal, P. 1974. *On Raising: One Rule of English grammar and Its Theoretical Implications*. Cambridge, MA: MIT Press.

Potsdam, E. and M. Polinsky. 2012. "Backward Raising." *Syntax* 15, 75–108. DOI: 10.1111/j.1467-9612.2011.00158.x.

Reinhart, T. 1976. *The Syntactic Domain of Anaphora*. PhD diss., MIT.

Riemsdijk, H. van and E. Williams. 1981. "NP-structure." *The Linguistic Review* 1, 171–217. DOI: 10.1515/tlir.1981.1.2.171.

Rosenbaum, P. 1967. *The Grammar of English Predicate Complement Constructions*. Cambridge, MA: MIT Press.

Ross, J. R. 1967. *Constraints on Variables in Syntax*. PhD diss., MIT.

Sag, I. A. and C. J. Pollard. 1991. "An Integrated Theory of Complement Control." *Language* 67, 63–113. DOI: 10.2307/415539.

Schütze, C. T. 2020. "Acceptability Ratings Cannot Be Taken at Face Value." In *Linguistic Intuitions*, edited by S. Schindler, A. Drozdzowicz, and K. Brøcker 189–214. Oxford: Oxford University Press.

Schütze, C. T. and J. Sprouse. 2013. "Judgment Data." In *Research Methods in Linguistics*, edited by R. J. Podesva and D. Sharma, 22–50. Cambridge: Cambridge University Press.

Speas, M. 1986. *Adjunctions and Projections in Syntax*. PhD diss., MIT.

Sprouse, J. and D. Almeida. 2012. "Assessing the Reliability of Textbook Data in Syntax: Adger's *Core Syntax*." *Journal of Linguistics* 48, 609–652. DOI: 10.1017/S0022226712000011.

Sprouse, J. and D. Almeida 2013. "The Empirical Status of Data in Syntax: A reply to Gibson and Fedorenko." *Language and Cognitive Processes* 28, 222–228. DOI: 10.1080/01690965.2012.703782.

Sprouse, J. and D. Almeida. 2017a. "Design Sensitivity and Statistical Power in Acceptability Judgment Experiments." *Glossa: A Journal of General Linguistics* 2 (1), e14. DOI: 10.5334/gjgl.236.

Sprouse, J. and D. Almeida. 2017b. "Setting the Empirical Record Straight: Acceptability Judgments appear to be Reliable, Robust, and Replicable." *Behavioral and Brain Sciences* 40, e311. DOI: 10.1017/S0140525X17000590.

Sprouse, J., C. T. Schütze and D. Almeida. 2013. "A Comparison of Informal and Formal Acceptability Judgments Using a Random Sample from *Linguistic Inquiry* 2001–2010." *Lingua* 134, 219–248. DOI: 10.1016/j.lingua.2013.07.002.

Travis, L. 1984. *Parameters and Effects of Word Order Variation*. PhD diss., MIT.

Wasow, T. and J. Arnold. 2005. "Intuitions in Linguistic Argumentation." *Lingua* 115, 1481–1496. DOI: 10.1016/j.lingua.2004.07.001.

Webelhuth, G. 1992. *Principles and Parameters of Syntactic Saturation*. Oxford: Oxford University Press.

5

The Chomsky Hierarchy[1]

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5.1 Introduction

An important cluster of closely related early Chomsky papers[2] had two major consequences. First, they defined a new branch of mathematics, formal language theory, which has flourished in its own right. But second, and more importantly for our purposes, this new branch of mathematics provided the formal grounding for a new conception of linguistics in which *grammars*, rather than sentences or collections of sentences, were the scientifically central objects: instead being derived from collections of sentences as compact summaries of observed regularities, grammars are seen as (ultimately mental) systems that determine the status of sentences. The "observed regularities" come to be seen as consequences of the structure of the underlying system, the grammar. The classification of grammars that became known as the Chomsky hierarchy was an exploration of what kinds of regularities could arise from grammars that had various conditions imposed on their structure.

Rather than laying out the mathematical theory in complete detail – numerous sources already provide this[3] – my aim in this chapter will be to focus on bringing out some key intuitions that emerge from the theory and try to highlight their applicability to theoretical linguistics. Looking at a completely formal treatment makes it easy to overestimate the degree to which the important concepts are bound to certain idealizations, such as the restriction to strings as the objects being generated and a binary grammaticality/ungrammaticality distinction.[4] While those idealizations *are there* in the theory, I hope to make the case that certain intuitions that emerge from the theory are meaningful and useful in ways that transcend those idealizations.[5] To the extent that I succeed in making this case, the reader will be able to turn to the formal literature with some motivating ideas in mind about the important concepts to watch out for.

One idea that plays a major role is the *intersubstitutability* of subexpressions. This is familiar from the distributional approach to discovering syntactic categories that is sometimes presented in introductory textbooks.[6] We reach the conclusion that *cat*

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and *dog* belong to the same category, for example, by noting that substituting one for the other does not change a sentence's grammaticality. While we might introduce the term "noun" or the book-keeping symbol N as a label for the class that *cat* and *dog* both belong to, there is nothing to being a noun other than being intersubstitutable with other nouns; the two-place predicate "belongs to the same category as" is more fundamental than the one-place predicate "is a noun." (This diverges from the view where a noun, for example, would be defined as a word that describes a person, place or thing.)

Intersubstitutability is closely related to the way different levels on the Chomsky hierarchy correspond to different kinds of memory. A grammar that will give rise to the intersubstitutability of *cat* and *dog* is one that ignores, or *forgets*, all the ways that they differ, collapsing all distinctions between them. Similarly for larger expressions: the distinctions between *wash the clothes* and *go to a bar*, such as the fact that they differ in number of words and the fact that only one of the two contains the word *the*, can be ignored. The flip side of this irrelevant information, that a grammar ignores, is the *relevant* information that a grammar tracks – this remembered, relevant information is essentially the idea of a category. Different kinds of grammars correspond to different kinds of memory in the sense that they differ in how these categories, this remembered information, are used to guide or constrain subsequent generative steps.

Much of the discussion below aims to show that this idea of intersubstitutability gets at the core of how any sort of grammar differs from a mere collection of sentences, and how any sort of grammar might finitely characterize an infinite collection of expressions. A mechanism that never collapsed distinctions between expressions would be forced to specify all combinatorial possibilities explicitly, leaving no room for any sort of productivity; a mechanism that collapsed all distinctions would treat all expressions as intersubstitutable and impose no restrictions on how expressions combine to form others. An "interesting" grammar is one that sits somewhere in between these two extremes, collapsing some but not all distinctions, thereby giving rise to constrained productivity – productivity stems from the distinctions that are ignored, while constraints stem from those that are tracked. The task of designing a grammar to generate some desired pattern amounts to choosing which distinctions to ignore and which distinctions to track.

5.2 Rewriting Grammars

We begin with the general concept of a string-rewriting grammar, which provides the setting in which the Chomsky hierarchy can be formulated.

5.2.1 Unrestricted Rewriting Grammars

An *unrestricted rewriting grammar* works with a specified set of *nonterminal symbols*, and specified set of *terminal symbols*. One of the nonterminal symbols is designated as the grammar's *start symbol*. The grammar also specifies a set of *rewrite rules* of the form $\alpha \rightarrow \beta$ where α is any non-empty string of nonterminal and terminal symbols, and β is any (possibly empty) string of nonterminal and terminal symbols. A rewrite rule $\alpha \rightarrow \beta$ says that from any string ϕ that contains α, we can derive a new string that is like ϕ but has α replaced with β. We say that a rewriting grammar *generates* a string s if s can be derived

from the grammar's start symbol via a sequence of steps using the grammar's rewrite rules, and s contains only terminal symbols.

It turns out that grammars of this sort are extremely powerful – in fact, they are general purpose computing devices, capable of carrying out any computation that a Turing machine is capable of.[7] For example, the grammar in Figure 5.1[8] emulates a machine that begins with the length-one string a, and "doubles" this string repeatedly to produce aa, then $aaaa$, then $aaaaaaaa$, before stopping at some point with the current string as output. I use uppercase letters for nonterminal symbols and letters in a different font for terminal symbols. So in the grammar in Figure 5.1, the set of nonterminal symbols is $\{S, L, R, F, B, X\}$, and the set of terminal symbols is $\{a\}$. The empty string is written as ε.

For any string s that we choose, the grammar in Figure 5.1 generates s if and only if the length of s is a power of two and no symbol other than a occurs in s. For convenience we sometimes say, using "generate" in a subtly different sense, that the grammar generates the set of strings that satisfy these conditions. A set of strings is

start symbol: S

i.	$S \rightarrow L\ F\ a\ R$
ii.	$F\ a \rightarrow a\ a\ F$
iii.	$F\ R \rightarrow B\ R$
iv.	$a\ B \rightarrow B\ a$
v.	$L\ B \rightarrow L\ F$
vi.	$L\ B \rightarrow L\ X$
vii.	$L\ X \rightarrow X$
viii.	$X\ a \rightarrow a\ X$
ix.	$X\ R \rightarrow \varepsilon$

(a) An unrestricted rewriting grammar

start:	S	
apply rule i:	L F a R	first doubling cycle
apply rule ii:	L a a F R	
apply rule iii:	L a a B R	
apply rule iv:	L a B a R	
apply rule iv:	L B a a R	
apply rule v:	L F a a R	second doubling cycle
apply rule ii:	L a a F a R	
apply rule ii:	L a a a a F R	
apply rule iii:	L a a a a B R	
apply rule iv:	L a a a B a R	
apply rule iv:	L a a B a a R	
apply rule iv:	L a B a a a R	
apply rule iv:	L B a a a a R	
apply rule vi:	L X a a a a R	cleaning up
apply rule vii:	X a a a a R	
apply rule viii:	a X a a a R	
apply rule viii:	a a X a a R	
apply rule viii:	a a a X a R	
apply rule viii:	a a a a X R	
apply rule ix:	a a a a	

(b) A derivation using this grammar

Figure 5.1 The nonterminal symbols L and R mark the left and right edge of the string. We begin with one occurrence of a between these markers; the nonterminal symbols F and B serve as a device that doubles this inner string to form aa, then $aaaa$, etc., arbitrarily many times. On each single "doubling cycle" of this device, F moves forward through the string replacing each occurrence of a with two (rule ii), and then B moves backward (rule iv) until it reaches the left edge. At the end of any such cycle, B can be replaced (rule vi) by the "cleaning up" symbol X, which deletes the left edge marker (rule vii), then moves rightward through the string (rule viii) to eventually delete the right edge marker (rule ix)

sometimes called a "stringset".[9] Thus the grammar in Figure 5.1 generates the stringset $\{a^n \mid n \text{ is a power of two}\} = \{a, aa, aaaa, aaaaaaaa, \ldots\}$.

Note that there is no direct connection between the notion of generation and that of sets: a grammar generates a set only by virtue of generating (all and only) the strings contained in it. While it is convenient to talk of "generating a set of strings," fundamentally it is strings that are generated, not sets – similarly, while it is convenient to talk of "eating a pile of apples," it is apples that are eaten, not piles.

5.2.2 Restrictions on Grammars

There are (at least) two reasons why we might question the usefulness of unrestricted rewriting grammars in our theories of natural language.

An obvious one, perhaps, is that since they can carry out any computational procedure at all, adopting this class of grammars would not constitute a meaningful hypothesis about what is a possible human language. This is an objection on the grounds of the *generative capacity* of the formalism.

The concern that is more prominent in Chomsky's early discussions, however, involves the notion of a *structural description*. This concern is not about the range of possible grammars made available by the formalism, but about what is said by the fact that a particular grammar generates a particular string. The idea is that if a grammar f generates a sentence x, then we would like to be able to identify "a structural description of x (with respect to the grammar f) giving certain information which will facilitate and serve as the basis for an account of how x is used and understood by speakers of the language whose grammar is f; i.e., which will indicate whether x is ambiguous, to what other sentences it is structurally similar, etc." (Chomsky, 1959, p. 138). Chomsky's chosen way to make this notion precise was to import the existing idea of "immediate constituent analysis" (Harris, 1946, 1954; Wells, 1947) and take trees of the now-familiar sort to be the desired kind of structural descriptions (Chomsky, 1959, p. 141).[10] But there is no obvious way to associate a derivation in an unrestricted rewriting grammar with a tree structure that provides an immediate constituent analysis for the generated string. For example, there is no natural way to assign such a tree structure to the string *aaaa* on the basis of the derivation shown in Figure 5.1. This is roughly because the grammar contains rules that do not simply replace a single symbol with a string (Chomsky and Miller, 1963, p. 294).

Another computational device that had attracted much attention in the 1950s was the finite-state automaton (FSA) (e.g. Rabin and Scott, 1959). Chomsky (1956) investigated the generative capacity of FSAs and concluded that it was insufficient for natural language, and showed that a certain sort of phrase structure grammar formalizing the notion of immediate constituent analysis could handle at least some cases that FSAs could not.[11]

The classes of rewriting grammars investigated in Chomsky 1959 are therefore motivated by the interest in "devices with more generative capacity than finite automata but that are more structured (and, presumably, have less generative capacity) than arbitrary Turing machines" (Chomsky, 1963, p. 360), the idea being that "the intermediate

Table 5.1 Three increasing restrictions on rewriting grammars

Restriction	**Required form of rules**	
Restriction 1, "context-sensitive"	$\phi A \psi \rightarrow \phi \omega \psi$	where ω is a non-empty string
Restriction 2, "context-free"	$A \rightarrow \omega$	where ω is a non-empty string
Restriction 3, "finite-state"	$A \rightarrow x$ or $A \rightarrow xB$	where x is a terminal symbol and B is a nonterminal symbol

systems are those that assign a phrase structure description to the resulting sentence" (Chomsky, 1959, p. 139). A sequence of three increasingly strict restrictions on rewriting grammars (Chomsky, 1959, p. 142) produces a hierarchy of classes of grammars, the broadest of which corresponds to Turing machines and the narrowest of which corresponds to finite-state automata.

These three restrictions are shown in Table 5.1. In this table, A stands for any nonterminal symbol, and ϕ and ψ stand for any (possibly empty) strings of terminal and nonterminal symbols. Notice that each of these restrictions requires that a rule replaces a single symbol with some non-empty string, in order to allow the possibility of constructing a tree expressing immediate-constituent structure from any derivation.[12]

To be precise, these are restrictions on the form that individual *rules* can take, and a grammar is of a certain type if and only if all of its rules satisfy the corresponding restriction. But notice that rules that satisfy Restriction 2 necessarily also satisfy Restriction 1 (by choosing ϕ and ψ to be the empty string), and similarly rules that satisfy Restriction 3 also satisfy both of the others. So these restrictions on the form of rules give us four classes of grammars:

(1) a. The Type 0 grammars are simply all unrestricted rewriting grammars.
b. The Type 1 grammars are those satisfying Restriction 1.
c. The Type 2 grammars are those satisfying Restriction 2 (and therefore also Restriction 1).
d. The Type 3 grammars are those satisfying Restriction 3 (and therefore also Restrictions 1 and 2).

The grammar in Figure 5.1 is a Type 0 grammar and does not belong to any of the more restricted classes, since rules such as "*a* B → B *a*" do not satisfy Restriction 1. It turns out, however, that there is a Type 1 grammar that generates this same powers-of-two stringset.[13] This raises the question of how these classes of grammars relate to generability of stringsets: are there stringsets that can be generated by a Type 0 grammar but not by any Type 1 grammar? Or is the extra rule-writing freedom that comes with Type 0 grammars actually inconsequential from the perspective of generable stringsets?

It turns out that all four classes of grammars are distinct in their generative capacity: at each boundary, there are stringsets that can be generated by a Type n grammar that cannot be generated by any Type $(n + 1)$ grammar. So there are, for example, Type 0 grammars that generate stringsets that no Type 1 grammar can generate – even if the Type 0 grammar in Figure 5.1 is not one of them.

5.3 Type 3 Grammars: Finite State Grammars

As mentioned above, Type 3 grammars were understood from the outset to be a reformulation of finite-state automata in the setting of rewriting grammars, so I will generally describe them as "finite-state grammars" (FSGs).

Figure 5.2 shows an example of a FSG in rewrite-rule format, and also the equivalent finite-state automaton in a standard graphical representation. A finite-state automaton works with a specified finite set of *states* (indicated with circles in the diagram) and a specified set of *(terminal) symbols*. One of the states is the designated *start state* (indicated with an unlabeled arrow), and some of the states are designated *accepting states* (indicated with a double circle). The workings of the automaton are specified as a set of *transitions*, each associating an ordered pair of states with a symbol, and represented graphically by an arrow.

A finite-state automaton generates a string *s* if and only if there is a connected sequence of transitions leading from the start state to an accepting state, that emit the symbols of *s* in order. For example, the automaton in Figure 5.2 generates *someone really ran*, but not *someone ran really* or *someone ran quickly*.

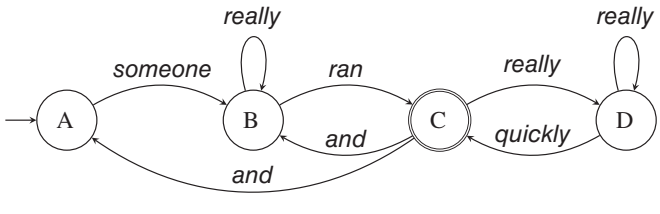
To see the connection between Type 3 rewriting grammars and finite-state automata, we associate states with nonterminal symbols, and in particular associate the start state of an automaton with the starting nonterminal of a grammar. The grammar's rewrite rules correspond to the automaton's transitions. Consider for example the transition from state A to state B emitting *someone*. If we think of each nonterminal *X* as characterizing all strings that can be used to move the automaton *from* state *X* to an accepting state, then the rewrite rule "A → *someone* B" says that a string can move the automaton from state A to an accepting state if it's made up of the symbol *someone* followed by a string that moves from state B to an accepting state. For transitions into an accepting state we include an additional rule with no nonterminal on the right hand side, such as "B → *ran*".

The string-rewriting derivation and the tree structure in Figure 5.3 both show that *someone ran and ran really quickly* is generated by both the rewriting grammar and the automaton in Figure 5.2.

start symbol: A

A	→	*someone* B
B	→	*really* B
B	→	*ran* C
B	→	*ran*
C	→	*and* A
C	→	*and* B
C	→	*really* D
D	→	*really* D
D	→	*quickly* C
D	→	*quickly*

(a) Rewrite-rule representation

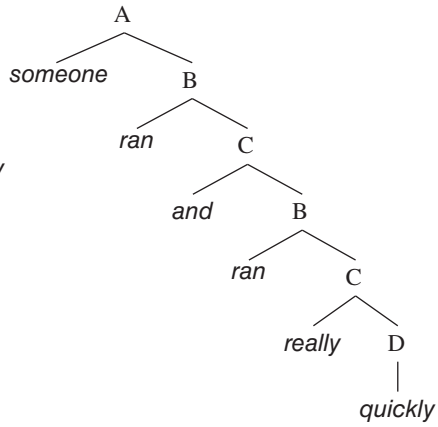


(b) Graphical representation

Figure 5.2 A simple finite-state grammar, represented graphically and as rewrite rules

A
someone B
someone ran C
someone ran and B
someone ran and ran C
someone ran and ran really D
someone ran and ran really quickly

(a) Rewriting derivation



(b) Tree diagram

Figure 5.3 Two equivalent representations of how the grammar in Figure 5.2 generates the string *someone ran and ran really quickly*

The central idea in understanding the capabilities and limitations of FSGs is what I will call a string's *forward set*. Adopting the automaton perspective, the forward set of a string s is the set of states that the automaton could reach from its initial state by taking some sequence of transitions that produce s. For example, if the automaton in Figure 5.2 has, from its initial state, taken some sequence of transitions that produces *someone ran*, then the only state that it might be in is C; so the forward set of *someone ran* (for this automaton) is {C}. Similarly, the forward set of *someone really* is {B}, the forward set of *someone ran and* is {A, B}, and the forward set of *someone and* is the empty set. The automaton generates a string if and only if the forward set of the string contains an accepting state.

Importantly, knowing the forward set of some initial part of a string (i.e. a *prefix* of the string, in formal terms) provides a head-start toward calculating the forward set of the entire string. For example, suppose we are told that the forward set (using the grammar in Figure 5.2) of some particular string s is {C}. Then, writing ++ for string concatenation, it is straightforward to see that the forward set of the string s ++ *really* is {D}, and that the forward set of s ++ *and* is {A, B}. We can be sure of this without knowing anything about s except its forward set. The forward set captures everything there is to know about how the automaton treats the prefix s; it identifies what we can think of as the category of that subexpression.

This leads us to the crucial idea of *intersubstitutability* mentioned in the introduction. Notice that *someone ran* and *someone really ran* both have the same forward set, namely {C}. So for any string t, the forward set of *someone ran* ++ t must be the same as the forward set of *someone really ran* ++ t – because in each case, all that matters is how the string t can "move us forward" from whatever states happen to be in the common forward set of *someone ran* and *someone really ran*. Furthermore, the two strings *someone ran* ++ t and *someone really ran* ++ t are either both generated by the grammar, or neither is, since these two strings' common forward set either does or doesn't contain an accepting state.

Table 5.2 Equivalence Classes Induced by the Grammar in Figure 5.2

Forward set	Example strings from the corresponding equivalence class
{A}	ε
{B}	*someone* *someone really* *someone really really* *someone ran and someone* *someone really ran and someone*
{C}	*someone ran* *someone really ran* *someone ran and ran* *someone ran and someone ran*
{D}	*someone ran really* *someone ran really really* *someone ran and someone ran really*
{A, B}	*someone ran and* *someone really ran and* *someone ran and someone ran and*
∅	*someone and* *someone someone* *and ran*

Stated generally, what we can conclude when two strings have the same forward set is that the relevant grammar treats them as intersubstitutable prefixes. So forward sets describe the way a grammar partitions prefixes into *equivalence classes*, collections of prefixes that are all intersubstitutable with each other. Table 5.2 shows the classes into which prefixes are partitioned by the grammar in Figure 5.2.

These intersubstitutability relationships also underlie the way "loops" in the structure of an FSG allow for the generation of infinitely many strings. A consequence of the loops in Figure 5.2 is that, for example, *someone really* and *someone really really* have the same forward set (namely {B}). Since these are therefore intersubstitutable, it follows that they are also both interchangeable with *someone really really really* – since we can substitute *someone really really* for the *someone really* part of itself. Any continuation that is compatible with one of these strings (e.g. the continuation *ran*) will be compatible with all others from the infinite class as well.

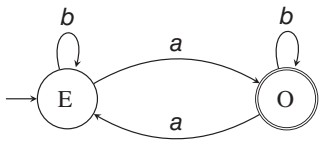
Figures 5.4 and 5.5 show some more abstract examples to sharpen these important points.

The grammar in Figure 5.4 requires that *a* occurs an odd number of times. Here, "what matters" about a prefix is just whether *a* occurs an odd or even number of times. The grammar reflects this by grouping all strings with an even number of *a*s together in the equivalence class represented by the forward set {E}; and similarly, for an odd number, the forward set {O}. See Table 5.3.

start symbol: E

E	→	*a* O
E	→	*a*
O	→	*a* E
E	→	*b* E
O	→	*b* O
O	→	*b*

(a) Rewrite-rule representation



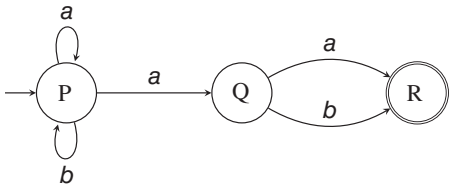
(b) Graphical representation

Figure 5.4 Two representations of a finite-state grammar requiring an odd number of *a*s

start symbol: P

P	→	*a* P
P	→	*b* P
P	→	*a* Q
Q	→	*a*
Q	→	*b*

(a) Rewrite-rule representation



(b) Graphical representation

Figure 5.5 Two representations of a finite-state grammar requiring that the second-last symbol is *a*

Table 5.3 Equivalence classes induced by the grammar in Figure 5.4

Contains an even number of *a*s	FORWARD SET: {E}
	EXAMPLE STRINGS: ε, *b*, *bb*, *aa*, *baa*, *aba*, *aab*, *abba*
Contains an odd number of *a*s	FORWARD SET: {O}
	EXAMPLE STRINGS: *a*, *ab*, *ba*, *bab*, *bba*, *aaa*, *aaba*, *baaa*

The grammar in Figure 5.5 requires that *a* be the second last symbol in a string. Part of what matters here is whether *a* was the second last symbol; we also need to track whether the *last* symbol was *a*, so that we know where we stand if one more symbol is added. These two yes-no questions create a four-way split, represented by the four forward sets shown in Table 5.4. The set of all possible strings is partitioned into these four classes, and knowing which of these four classes a string belongs to provides everything an automaton needs to know in order to enforce appropriate requirements on what follows. For example, any two strings with *a* in the last position but not the second last position will both have forward set {P, Q}, and will therefore be treated as intersubstitutable.

These examples bring out an important intuition that is likely familiar to linguists: designing a grammar amounts to choosing "what to remember" about intermediate subexpressions, and what can be ignored. It is exactly this move of ignoring distinctions between subexpressions that allows a finitely specified grammar to generate unboundedly many expressions. A device that never allowed itself to "forget," or ignore, *some* aspects of an expression's internals, would be one where the applicability of a

Table 5.4 Equivalence classes induced by the grammar in Figure 5.5

	Second-last symbol is not *a*	Second-last symbol is *a*
Last symbol is not *a*	FORWARD SET: {P} EXAMPLE STRINGS: ε, *b*, *bb*, *abb*	FORWARD SET: {P, R} EXAMPLE STRINGS: *ab*, *aab*, *bab*
Last symbol is *a*	FORWARD SET: {P, Q} EXAMPLE STRINGS: *a*, *ab*, *aba*, *bba*	FORWARD SET: {P, Q, R} EXAMPLE STRINGS: *aa*, *aaa*, *baa*

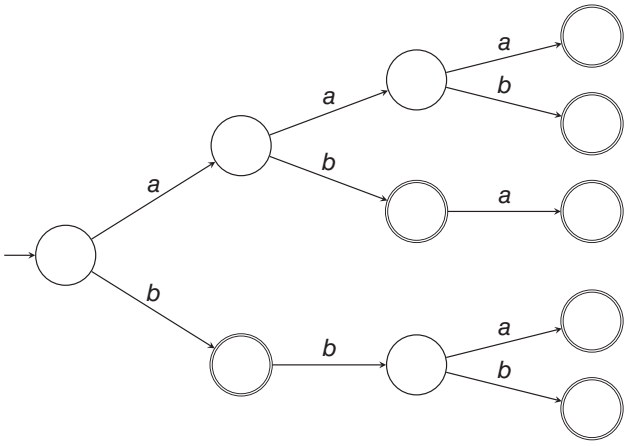


Figure 5.6 A boring finite state automaton where states stand in a one-to-one correspondence with prefixes

grammatical rule is dependent on the *entire* surrounding context, and would simply amount to a finite list of expressions. The automaton in Figure 5.6 is of this uninteresting sort: each state serves to remember an entire prefix, so no two distinct prefixes are "grouped together" by virtue of sharing a forward set, and the automaton simply encodes an arbitrary finite set of strings (namely {*b*, *ab*, *aaa*, *aab*, *aba*, *bba*, *bbb*}). This set exhibits no interesting patterns because the automaton has no interesting structure.

Given the central role of this partitioning of strings into classes, a natural question that arises is what sorts of partitionings are possible. How large can the number of classes induced by a finite-state grammar get? There is no upper limit, but the number of classes *must be finite*.[14] This follows from the fact that the number of states is finite: each equivalence class is identified by a subset of the set of states, and if the set of states is finite then it has only finitely many subsets.

The requirement that there only be finitely many equivalence classes allows us to succinctly identify the limitations of FSGs. Consider, for example, trying to construct an FSG for $a^n b^n$ (for $n \geq 1$). First note that the prefix *a* is not intersubstitutable with *aa*, since one but not the other will lead to a well-formed string when followed by *bb*. Similarly, neither of these prefixes is intersubstitutable with *aaa*. So the three strings *a*, *aa*, and *aaa* need to be split up into three distinct equivalence classes. In fact, as we go further down the list to *aaaa*, *aaaaa*, *aaaaaa* and so on, we will never find two such strings

of *a*s that are intersubstitutable. No finite number of equivalence classes will be enough to track all the relevant distinctions. But for any finite number of states, there are only *finitely many different possible forward sets*; any FSG will, eventually, assign two different strings of *a*s – say, a^{73} and a^{94} – the same forward set, and will therefore incorrectly treat them as intersubstitutable prefixes (e.g. incorrectly generating $a^{73}b^{94}$ and $a^{94}b^{73}$ in addition to $a^{73}b^{73}$ and $a^{94}b^{94}$).

There is something natural about this idea: a grammar (or a mind) can only contain finitely many rules, and each rule specifies some allowable "use" for finitely many classes of expression, picked out by states or nonterminal symbols. Even if we somehow sliced up the space of all possible expressions into infinitely many equivalence classes, any finite grammar would not contain enough rules to define uses for all of those classes.

5.4 Type 2 Grammars: Context-Free Grammars

A Type 2 or context-free grammar (CFG) allows the right-hand side of a rule to be any mixture of nonterminal and terminal symbols. A classic example, which generates the a^nb^n (for $n \geq 1$) stringset, is shown in (2). A derivation using this grammar is in (3).

(2) start symbol: S

S → *aSb*
S → *ab*

(3) S

aSb
aaSbb
aaaSbbb
aaaaSbbbb
aaaaabbbbb

It is helpful to consider exactly how this CFG manages to do what no FSG can. What made this pattern impossible for an FSG is that the endless collection of prefixes *a*, *aa*, *aaa*, etc. cannot all be "kept separate" by a function that maps each prefix to a subset of a finite number of states. But a CFG still has only a finite number of rules, which specify the behaviour of a finite number of nonterminal symbols; one way or another, a CFG must boil down to a collection of rules that specify finitely many ways in which subexpressions of finitely many different classes can be combined. How can this finiteness be reconciled with the fact that a CFG can generate the a^nb^n pattern?

The answer is that while a FSG is limited to classifying strings according to their role as *prefixes* (i.e. according to what can come *after* them), a CFG is able to classify strings according to their role as *infixes* (i.e. according to what can come *around* them). The CFG in (2) does not work by specifying what can come after *aa*, and what can come after *aaa*, etc.; as we have seen, any finite device that adopts this strategy is doomed. Instead, this grammar works by specifying what can appear *around* certain strings, and the crucial point is that what can appear around, say, *aabb*, is the same as what can appear around *aaabbb* – so while the pattern a^nb^n does not create any interesting equivalences between prefixes, it *does* create interesting equivalences between

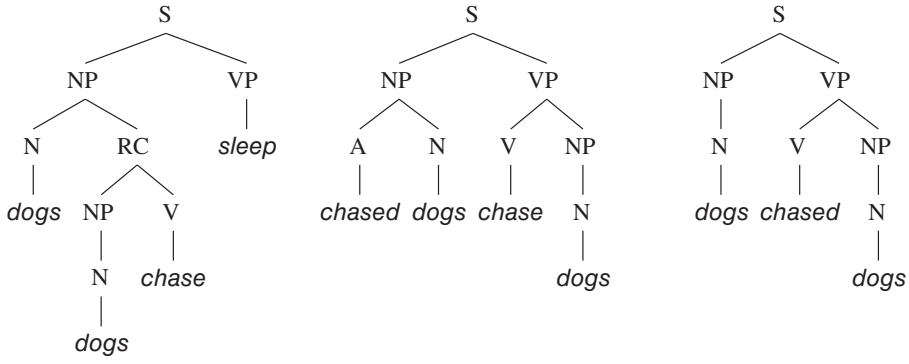
infixes. The grammar in (2) takes advantage of this by making a two-way distinction between (i) strings of the form $a^i b^i$, which can be combined with any surroundings of the form a^j__b^j, and (ii) all other strings. It uses the nonterminal symbol S as a book-keeping symbol to identify strings belonging to the first class, just as FSGs use states.

To see these concepts in a more familiar form, consider the CFG in (4). A few example derivations are illustrated with tree diagrams in (5). The stringset that this grammar generates also cannot be generated by any FSG: among strings of the form *dogs***chase***sleep*, only those where there is exactly one occurrence of *chase* for each occurrence of *dogs* after the first one will be generated (i.e. those of the form *dogs dogs*^{n}*chase*^{n}*sleep*), so there are unboundedly many nonequivalent prefixes of the form *dogs*^{i}. The early rejection of FSGs as models of natural language was based on the claim that a grammar of English would need to generate patterns of essentially this sort (Chomsky, 1956, §2.3).

(4) start symbol: S

S	→	NP VP	N	→	*dogs*
NP	→	N	A	→	*chased*
NP	→	A N	A	→	*big*
NP	→	N RC	V	→	*chased*
RC	→	NP V	V	→	*chase*
VP	→	V NP	VP	→	*sleep*

(5)



Subsets of the set {S, NP, VP, RC, N, A, V} of nonterminals characterize classes of strings, grouped according to the ways they can appear as infixes. I will call these sets *inside sets*: for example, the inside set of the string *chase big dogs* is {VP}, and the inside set of *chased dogs* is {VP, NP}; see Table 5.5. This partitioning of strings is the CFG's analog of an FSG's partitioning of strings by forward sets, and corresponds to the familiar notion of categorized constituents. A typical motivation for writing a grammar where a single nonterminal can derive, say, both *sleep* and *chase dogs*, is to express the idea that they are *intersubstitutable infixes*, i.e. for any two strings u and v, if u ++ *sleep* ++ v is generated then u ++ *chase dogs* ++ v is also generated. This is the sense in which CFGs carry over earlier ideas from immediate constituent analysis (e.g. Harris, 1946, 1954; Wells, 1947). For more recent discussions of this important notion, see Clark (2013), Clark and Yoshinaka (2016) and Stabler (2019, Section 2).

Table 5.5 Equivalence classes induced by the grammar in (4)

Inside set	Example strings from the corresponding equivalence class
{S}	*dogs sleep* *dogs dogs chase sleep* *chased dogs chase dogs* *dogs chased dogs*
{NP}	*dogs* *big dogs* *dogs dogs chase* *dogs dogs dogs chase chase*
{VP}	*sleep* *chase dogs* *chased dogs dogs chase* *chased big dogs*
{RC}	*dogs chase* *dogs chased* *big dogs chased*
{N}	*dogs*
{A}	*big*
{V}	*chase*
{A, V}	*chased*
{NP, VP}	*chased dogs*
∅	*dogs dogs* *sleep chased* *big dogs chased*

Like forward sets, the inside set of a string (relative to a particular CFG) can be computed recursively from the inside sets of the string's parts. Recall that the forward set of a string $x_1x_2x_3x_4$, for example, can be computed by considering the states in the forward set of $x_1x_2x_3$, and asking which of these states have an outgoing transition emitting x_4. The situation for inside sets is similar. Considering only rules of the form "$A \rightarrow B\ C$" for ease of exposition: to compute the inside set of $x_1x_2x_3x_4$, we must consider the inside set of x_1x_2 and ask whether any of its member nonterminals can be combined with any nonterminal in the inside set of x_3x_4; but also consider combinations drawing one nonterminal from the inside set of x_1 and one from that of $x_2x_3x_4$, *plus* combinations drawing one from the inside set of $x_1x_2x_3$ and one from that of x_4. (The inside set of a length-one string x, we can assume, is just the set of nonterminals A for which the grammar contains the rule $A \rightarrow x$.)[15] The upshot is that to work out the inside set of $x_1x_2x_3x_4$, it suffices to know the inside sets of all its substrings. This is more complex than the situation for forward sets because there are multiple "splits" to consider (as opposed to only splitting into $x_1x_2x_3$ and x_4); but it is analogous in the important sense

that inside sets tell us everything there is to know about how the grammar treats the relevant subexpression.

This freedom to split strings into pieces in arbitrary ways underlies a CFG's ability to create classes of intersubstitutable *infixes*. For example, consider the first tree in (5): the fact that we can split the *last* word off *dogs dogs chase sleep* but then split the *first* word off *dogs dogs chase* leads to the end result that the overall string is split into an infix *dogs chase* and its surroundings *dogs__sleep*. The nonterminal symbol RC serves as a hinge or pivot that links together these two pieces – *dogs chase*, which can appear "inside" RC, and *dogs__sleep*, which can appear "outside" it – just as the state B in Figure 5.2, for example, links together *someone ran and* and *ran really quickly*.

In an important sense, what distinguishes CFGs from FSGs is not directly an issue of hierarchical tree structure or constituency – the tree in Figure 5.3 is hierarchical, expressing part-whole relationships among constituents, in at least one sense – but rather, the distinction between being able to make infix-circumfix splits and being restricted to prefix-suffix splits. Specifically, the stringsets that can be generated by a CFG but not by any FSG are those for which every CFG is "self-embedding" (Chomsky, 1959, p. 167), i.e. those where some string can be substituted for a proper infix of itself, such as the way *aabb* can be substituted for *ab* in the $a^n b^n$ stringset. The relevant equivalence classes are still classes of strings, and are based on the way substrings fit into larger strings.

What sorts of stringsets *cannot* be generated by the infix-based mechanisms of a CFG? The comparison between the stringsets L_{pal} and L_{repeat} defined in (6) is instructive (Chomsky and Miller, 1963, pp. 285–287). Some notation: w^R is the reverse of a string w, and $\{a, b\}^+$ is the set of all non-empty strings using the symbols *a* and *b*. So L_{pal} is the set of even-length palindromes, and L_{repeat} is the set of strings whose second half simply repeats the first half.

(6)
$$L_{\text{pal}} = \{ww^R \mid w \in \{a, b\}^+\}$$
$$= \{aa, bb, aaaa, abba, baab, bbbb, aaaaaa, aabbaa, \ldots\}$$

$$L_{\text{repeat}} = \{ww \mid w \in \{a, b\}^+\}$$
$$= \{aa, bb, aaaa, abab, baba, bbbb, aaaaaa, aabaab, \ldots\}$$

There is a CFG that generates L_{pal}, shown in (7).

(7)
$$\text{S} \rightarrow aSa$$
$$\text{S} \rightarrow bSb$$
$$\text{S} \rightarrow aa$$
$$\text{S} \rightarrow bb$$

It may seem at first surprising, then, that no CFG can generate L_{repeat}, since it is simply L_{pal} without the reversal. But the ww^R notation obscures the way that the CFG in (7) actually works. Importantly, this CFG generates *abaaba* *not* by combining the prefix *aba* with the suffix *aba*, but rather, by combining the infix *baab* with the surroundings *a__a*, using the first rule shown in (7). An infix-based analysis of L_{repeat}, however, is no help.

5.5 Beyond Context-Free Grammars

From the very outset there were doubts about about whether CFGs could form the basis of a theory of natural language syntax. Chomsky (1956, Section 4) argued that even if the generative capacity of CFGs (unlike FSGs) turned out to be sufficient for English (a question he left open), the resulting grammars would be unreasonably complex.[16] Relatedly, one motivation for considering Type 1 rules in the first place was the recognition that, in practice, linguists found uses for contextual restrictions on rewrite rules, for example to state selectional restrictions (Chomsky, 1959, p. 148; Chomsky and Miller, 1963, p. 295; Chomsky, 1963, p. 363).

Furthermore, it has more recently been discovered that CFGs might be insufficient, even on the straightforward basis of generative capacity, to describe some natural languages. The best-known case is a construction in Swiss-German (Shieber, 1985) that exhibits *crossing dependencies* of the sort exhibited by L_{repeat} in (6); these contrast with the *nested dependencies* exhibited by L_{pal}, which are neatly handled by CFGs. See e.g. Pullum (1986), Partee et al. (1990, pp. 503–505), Frank (2004), Kallmeyer (2010, pp. 17–20) and Jäger and Rogers (2012) for useful discussion; ideas closely related to the crucial point about Swiss-German can be traced back to Huybregts (1976, 1984) and Bresnan et al. (1982).

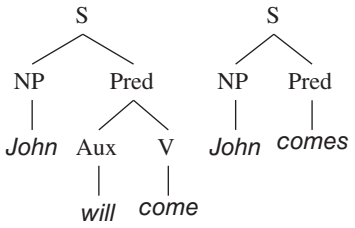
But despite these reasons for looking beyond CFGs, Type 1 or *context-sensitive* grammars (CSGs) have not proven to be a particularly useful tool for linguistics; they have turned out to be "too close" to unrestricted rewriting grammars. While CSGs can generate the crossing-dependency patterns of L_{repeat} and Swiss-German, their generative capacity extends far beyond this. For example, there is even a CSG that generates $\{a^n \mid n \text{ is prime number}\}$.[17] The sense that this stringset seems not at all "language-like" plausibly stems from the property of CSGs that caused Chomsky the most concern initially: contextually restricted rewrites produced structural descriptions that could not be interpreted along the lines of immediate constituent analysis. Immediately after showing that CSGs could generate stringsets that no CFG could generate, Chomsky (1959, p. 148) surmised that "the extra power of grammars that do not meet Restriction 2 appears … to be a defect of such grammars, with regard to the intended interpretation." The underlying issue here is the absence of any meaningful kind of *intersubstitutability* at the core of CSGs: what distinguishes a Type 1 grammar from FSGs and CFGs is exactly the fact that the substrings derivable from a symbol A in the context $\phi__\psi$ might *not* be derivable from A in another context.

Chomsky's discussion of the undesirable properties of CSGs focuses on their ability to, in effect, reorder constituents. For example, a permuting rule "CD → DC," which does not itself satisfy Restriction 1 (recall that the Type 0 grammar in Figure 5.1 contains rules like this), can be mimicked by a sequence of Type 1 rules "CD → XD → XC → DC" (Chomsky, 1959, p. 148; Chomsky, 1963, p. 365). Chomsky considers using this kind of reordering to derive a question form such as *will John come* in a way that relates it to its corresponding declarative *John will come*. The CSG in (8) shows how this would work. The first group of rules shown in (8) generates the declaratives *John will come* and *John comes* as shown in (9); these are all context-free rules, and notice that they correctly capture the intersubstitutability of *will come* with *comes*, via the nonterminal Pred. The second group of rules in (8) serves to turn "NP Aux" into "Aux NP"; in particular, the derivation in (10) uses them to derive "Aux NP *come*," and then eventually *will John come*, from the (canonically ordered, intuitively) "NP Aux *come*."

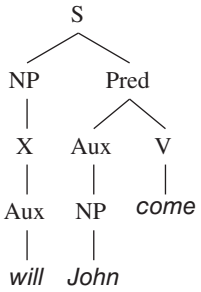
(8) S → NP Pred
NP → *John*
Pred → Aux V
Pred → *comes*
Aux → *will*
V → *come*

NP Aux → X Aux
X Aux → X NP
X NP → Aux NP

(9)



(10) S
NP Pred
NP Aux V
NP Aux *come*
X Aux *come*
X NP *come*
Aux NP *come*
Aux *John come*
will John come



The fact that each step of the derivation in (10) rewrites only a single nonterminal symbol ensures that we *can* construct a tree structure that indicates which parts of the eventual string were derived from which nonterminal symbols.[18] (This would not be possible for a derivation that implemented the reordering directly with the rule "NP Aux → Aux NP"; recall Figure 5.1.) But the resulting tree structure says "that *will* in this sentence is a noun phrase … and that *John* is a modal auxiliary, contrary to our intention" (Chomsky, 1963, p. 365). This result is undesirable because we do not want *will* to be *in general* intersubstitutable with *John*, or the other strings that we would expect to be derivable from the nonterminal symbol NP if this tiny grammar were expanded. So the labeled constituency relationships that can be read off the trees associated with Type 1 derivations are not interpretable as statements about intersubstitutability, as they are in more restricted grammars. In other words, Restriction 1's requirement that each derivational step rewrites only a single nonterminal symbol turned out to be insufficient to capture the important linguistic intuitions regarding categorization and intersubstitutability that underlie immediate constituent analysis.

In the light of more recent developments, the difficulties raised by the issue of reordering can be seen as stemming from the tight connection between intersubstitutability (in

the sense that can be captured in rewriting systems of the sort Chomsky was exploring) and *linear contiguity*. Only linearly contiguous strings of symbols have the chance to be placed in an equivalence class. While familiar, there is nothing necessary about this connection: a sub-part of a string might belong to a class of intersubstitutable subexpressions without being contiguous. In this case, the relevant sub-parts will not themselves be strings, but will be tuples of strings. To illustrate, it suffices to consider tuples of size two, i.e. pairs of strings that are co-dependent, and together constitute an expression belonging to a meaningful grammatical category, but need not be pronounced together. For example:

(11) a. The pair (*will*, *come*) and the pair (*must*, *leave*) are intersubstitutable, in the sense that we can replace the former with the latter in *will the students come* to produce *must the students leave*. (As well as in *John will come* to produce *John must leave*.)
b. The pair (*John*, *to be tall*) and the pair (*the girl*, *to win*) are intersubstitutable, in the sense that we can replace the former with the latter in *John is likely to be tall* to produce *the girl is likely to win*.[19]
c. The pair (*buy*, *which book*) and the pair (*eat*, *what*) are intersubstitutable, in the sense that we can replace the former with the latter in *which book did you buy yesterday* to produce *what did you eat yesterday*.

Chomsky's chosen approach to these phenomena, the notion of a grammatical transformation – extensively elaborated elsewhere (e.g., Chomsky, 1957, 1965) but formally somewhat removed from the work described here – was one way to resolve the tension created by the conflation of intersubstitutability and contiguity.[20] In the transformational approach, the patterns described in (11) are handled by first deriving a structure in which the co-dependent elements (e.g., *will* and *come*, or *John* and *to be tall*) are linearly contiguous, in a *base component* which functions essentially like a CFG and therefore ties contiguity and intersubstitutability together. This correctly prevents generating an expression that contains *will* without an accompanying verb like *come* (see (9)), or contains *which book* without a verb to select it, or contains the predicate *be tall* without a subject – but at the cost of grouping these co-dependent elements together in ways that do not align with their relative linear positions. The *transformational component* resolves the tension created by tying co-occurrence to contiguity, transforming a structure that has such co-dependent elements adjacent into one where they are separated.

But another logically possibility, when we are confronted with the patterns in (11), is to simply break the link between co-dependence and linear contiguity right from the beginning. Multiple context-free grammars (MCFGs) (Seki et al., 1991) provide a canonical instantiation of this option; see, e.g., Kallmeyer (2010, ch. 6) and Clark (2014) for overviews. Derivations in these grammars are most naturally understood in terms of a "bottom-up" composition process, unlike the "top-down" rewriting grammars that serve as the framework for the Chomsky hierarchy. MCFGs have proven to be a useful reference point for understanding and comparing various *mildly context-sensitive* grammar formalisms (Joshi, 1985; Joshi et al., 1990), which sit between CFGs and CSGs on the scale of generative capacity, including formalisms expressed in terms of transformation-like tree-manipulating operations, such as Minimalist Grammars (Stabler, 1997, 2011) and Tree-Adjoining Grammars (Joshi et al., 1975; Abeillé and Rambow, 2000; Frank, 2002).

5.6 Conclusion

The notion of intersubstitutability of subexpressions, or categorization of subexpressions into equivalence classes, is tightly related to the very idea of a grammar itself. Grammar formalisms differ in the ways that they compose these subexpressions (e.g. prefix-suffix combinations, infix-circumfix combinations), but this composition is mediated by categorization. Any interesting system of categorization involves isolating out the properties of a subexpression that affect its combinatory potential, and those that don't; those properties that need to be remembered or tracked, and those that can be safely ignored or forgotten. If everything is remembered and nothing is forgotten, a grammar reduces to a list of stored complete expressions (recall Figure 5.6); at the other extreme, a grammar that remembers nothing treats all subexpressions interchangeably, and therefore generates a set of expressions that exhibits no regularities. An interesting grammar is one that sits in between these two extremes, yielding constrained productivity.

The overall perspective that I have offered here is somewhat more optimistic about lasting contributions of the Chomsky hierarchy than linguists have generally been since the 1960s – not more optimistic about the role string-generating grammars can play in linguistic theory, but more optimistic about the role that insights gleaned from the careful study of string-generating grammars can play in an understanding of any kind of grammar.

Endnotes

1 Thanks to Bob Frank, Bruce Hayes, Jeff Heinz, Norbert Hornstein, Kyle Johnson, Paul Pietroski, and the editors and reviewers for helpful comments and suggestions on earlier drafts.

2 Chomsky (1956), Chomsky and Miller (1958), Chomsky (1959, 1963), Chomsky and Miller (1963), Miller and Chomsky (1963).

3 For standard presentations from the general perspective of the theory of computation, see e.g. Hopcroft and Ullman (1979), Lewis and Papadimitriou (1981) and Sipser (1997). For more linguistics-oriented presentations, see e.g. Levelt (1974), Partee et al. (1990).

4 For generalizations beyond the case of strings as the generated objects, see the rich literature on tree grammars (e.g. Thatcher, 1967, 1973; Thatcher and Wright, 1968; Rounds, 1970; Rogers 1997; Comon et al. 2007). Generalizations beyond binary grammaticality arise via the theory of semirings (e.g. Kuich 1997; Goodman 1999; Mohri 2002).

5 Notice that the argument here does not concern the usefulness of the traditional notion of weak generative capacity that emerges from the original work on the Chomsky hierarchy, or the viewpoint which equates natural languages with sets of strings and asks where those sets of strings fall on the hierarchy (or extensions of it). The main point I hope to make here is that the usefulness of the Chomsky hierarchy for theoretical linguistics need not be limited to what emerges from those traditional and better-known perspectives.

6 See e.g. Carnie (2013, pp. 48–50), Fromkin et al. (2000, pp. 147–151). Johnson (2019) gives a particularly clear presentation of the fundamental relationship between substitution classes and phrase structure.

7 See e.g. Chomsky (1963, pp. 358–359), Levelt (1974, pp. 106–109), Partee et al. (1990, pp. 516–517), Hopcroft and Ullman (1979, pp. 221–223).

8 This is based on an example from Hopcroft and Ullman (1979, pp. 220–221).

9 Much of the technical literature uses the term "language" here, but this creates unnecessary distractions.

10 See also Chomsky, 1956, Section 3.1; Chomsky and Miller, 1963, pp. 288–289.

11 The phrase structure grammars considered in section 3 of Chomsky (1956) do not correspond exactly to any of the classes in (1) that are discussed in Chomsky (1959).

12 Citing Harris, 1951, Chomsky (2006, p. 172, fn.15) writes that "The concept of 'phrase structure grammar' was explicitly designed to express the richest system that could reasonably be expected to result from the application of Harris-type procedures to a corpus."

13 Hopcroft and Ullman (1979, p. 224) show that this stringset can be generated by a grammar consisting of rules $\alpha \rightarrow \beta$ where β is at least as long as α. The stringsets generable by grammars satisfying this "non-contracting" requirement are the same as those generable by Type 1 grammars (Chomsky, 1959, pp. 144–145). The non-contracting requirement is sometimes given as an alternative condition defining Type 1 grammars, e.g. Levelt (1974, pp. 27–29). Chomsky (1963, pp. 360–363), departing from the Chomsky, 1959 numbering system that has now become standard, defines Type 1 grammars with the non-contracting requirement, and calls grammars with rules satisfying the $\phi A \psi \rightarrow \phi \omega \psi$ format "Type 2 grammars."

14 This is the Myhill-Nerode Theorem (e.g. Hopcroft and Ullman, 1979, p. 65).

15 This logic is the basis of the CKY algorithm, due to Cocke and Schwartz (1970), Kasami (1965) and Younger (1967); see also Hopcroft and Ullman (1979, pp. 139–141).

16 "I do not know whether English is actually a terminal language or whether there are other actual languages that are literally beyond the bounds of phrase structure description. Hence I see no way to disqualify this theory of linguistic structure on the basis of [generative capacity]. When we turn to the question of the complexity of description … , however, we find that there are ample grounds for the conclusion that this theory of linguistic structure is fundamentally inadequate." (Chomsky, 1956, Section 4). See also Chomsky and Miller (1963, p. 297).

17 This follows from the relationship between CSGs and linear bounded automata; see e.g. Hopcroft and Ullman (1979, p. 225).

18 I am leaving aside here the issues raised by rules like XZ → XYZ, which, because they satisfy Restriction 1 "in two ways," do not let us uniquely identify a tree structure for each derivation; and therefore do not even let us say which strings are derived from which nonterminal symbols in any sense. This can be overcome by simply requiring that such rules be reformulated as either "X → XY / _ Z' or 'Z → YZ / X _." For other discussions of the relationship between Type 1 grammars and tree structures, see Partee et al. (1990, pp. 448–450) and Levelt (1974, pp. 29–31).

19 This is closely analogous to the point made by the wrap operation introduced by Bach (1979), modulo the distinction between raising and control.

20 Chomsky (1956, Section 4.1) briefly mentions that the move from CFGs to transformational grammars introduces the possibility of "selecting as elements certain discontinuous strings," for example (*has*,*-en*) and (*be*,*-ing*). But this perspective on transformational grammars seems to have not been discussed much otherwise.

References

Anne Abeillé and Owen Rambow. 2000. *Tree Adjoining Grammars*. Stanford, CA, CSLI Publications.

Emmon Bach. Control in Montague Grammar. 1979. *Linguistic Inquiry* 10 (4):515–531.

Joan Bresnan, Ronald M. Kaplan, Stanley Peters, and Annie Zaenen. 1982. Cross-serial Dependencies in Dutch. *Linguistic Inquiry* 13 (4):613–635.

Andrew Carnie. 2013. *Syntax: A Generative Introduction*. Malden, MA: third edition, Wiley-Blackwell.

Noam Chomsky. 1956. Three models for the description of language. *IRE Transactions on Information Theory* 2 (3):113–124.

Noam Chomsky. 1957. *Syntactic Structures*. Mouton, The Hague.

Noam Chomsky. 1959. On certain formal properties of grammars. *Information and Control* 2:137–167.

Noam Chomsky. 1963. Formal properties of grammars. In R. Duncan Luce, Robert R. Bush, and Eugene Galanter, editors, *Handbook of Mathematical Psychology*, volume 2, pages 323–418. John Wiley and Sons, Inc., New York and London.

Noam Chomsky. 1965. *Aspects of the Theory of Syntax*. MIT Press, Cambridge, MA.

Noam Chomsky. 2006. *Language and Mind*. Cambridge University Press, 3rd edition.

Noam Chomsky and George Miller. 1963. Introduction to the formal analysis of natural languages. In R. Duncan Luce, Robert R. Bush, and Eugene Galanter, editors, *Handbook of Mathematical Psychology*, volume 2, pages 269–321. John Wiley and Sons, Inc., New York and London.

Noam Chomsky and George A. Miller. 1958. Finite state languages. *Information and Control* 1 (2):91–112,

Alexander Clark. 2013. The syntactic concept lattice: Another algebraic theory of the context-free languages? *Journal of Logic and Computation* 25 (4):1203–1229.

Alexander Clark. 2014. An introduction to multiple context-free grammars for linguists. `https://alexc17.github.io/papers/mcfgsforlinguists.pdf`.

Alexander Clark and Ryo Yoshinaka. 2016. Distributional learning of context-free and multiple context-free grammars. In Jeffrey Heinz and José M. Sempere, editors, *Topics in Grammatical Inference*, pages 143–172. Springer.

John Cocke and J. T. Schwartz. 1970. Programming languages and their compilers. Courant Institute of Mathematical Sciences, New York University.

H. Comon, M. Dauchet, R. Gilleron, C. Löding, F. Jacquemard, D. Lugiez, S. Tison, and M. Tommasi. 2007. Tree automata: Techniques and applications. Available from: `http://www.grappa.univ-lille3.fr/tata`. Release October, 12th 2007.

Robert Frank. 2002. *Phrase Structure Composition and Syntactic Dependencies*. MIT Press, Cambridge, MA.

Robert Frank. 2004. Restricting grammatical complexity. *Cognitive Science* 28 (5).

Victoria Fromkin, Susan Curtiss, Bruce P. Hayes, Nina Hyams, Patricia A. Keating, Hilda Koopman, Pamela Munro, Dominique Sportiche, Edward P. Stabler, Donca Steriade, Tim Stowell, and Anna Szabolsci. 2000. *Linguistics: An Introduction to Linguistic Theory*. Blackwell.

Joshua T. Goodman. 1999. Semiring parsing. *Computational Linguistics* 25 (4): 573–605.

Zellig S. Harris. 1946. From morpheme to utterance. *Language* 22 (3):161–183.

Zellig S. Harris. 1951. *Methods in Structural Linguistics*. University of Chicago Press.

Zellig S. Harris. 1954. Distributional structure. *Word* 10 (2–3):146–162.

John E. Hopcroft and Jeffrey D. Ullman. 1979. *Introduction to Automata Theory, Languages and Computation*. Addison Wesley, Reading, MA.

Riny Huybregts. 1976. Overlapping dependencies in dutch. In *Utrecht Working Papers in Linguistics*, number 1, pages 24–65.

Riny Huybregts. 1984. The weak inadequacy of context-free phrase structure grammars. In Ger J. de Haan, Mieke Trommelen, and Wim Zonneveld, editors, *Van Periferie Naar Kern*, pages 81–99. Foris, Dordrecht.

Gerhard Jäger and James Rogers. 2012. Formal language theory: refining the Chomsky hierarchy. *Philosophical Transaction of the Royal Society B* 367: 1956–1970.

Kyle Johnson. 2019. Transformational grammar. Unpublished course notes.

Aravind Joshi. 1985. How much context-sensitivity is necessary for characterizing structural descriptions? In David Dowty, Lauri Karttunen, and Arnold Zwicky, editors, *Natural Language Processing: Theoretical, Computational and Psychological Perspectives*, pages 206–250. Cambridge University Press, New York.

Aravind K. Joshi, Leon S. Levy, and Masako Takahashi. 1975. Tree adjunct grammars. *Journal of Computer and System Sciences* 10:136–163.

Aravind K. Joshi, K. Vijay Shanker, and David Weir. 1990. The convergence of mildly context-sensitive grammar formalisms. University of Pennsylvania Department of Computer and Information Science Technical Report No. MS-CIS-90-01.

Laura Kallmeyer. 2010. *Parsing Beyond Context-Free Grammars*. Springer-Verlag, Berlin Heidelberg.

Tadao Kasami. 1965. An efficient recognition and syntax-analysis algorithm for context-free languages. AFCRL Technical Report 65-758.

Werner Kuich. 1997. Semirings and formal power series: their relevance to formal languages and automata. In Grzegorz Rozenberg and Arto Salomaa, editors, *Handbook of Formal Languages*, volume 1, pages 609–677. Springer.

Willem J. M. Levelt. 1974. *An Introduction to the Theory of Formal Languages and Automata*, volume 1 of *Formal Grammars in Linguistics and Psycholinguistics*. Mouton.

Harry R. Lewis and Christos H. Papadimitriou. 1981. *Elements of the Theory of Computation*. Prentice-Hall.

George A. Miller and Noam Chomsky. 1963. Finitary models of language users. In Robert Duncan Luce, Robert R. Bush, and Eugene Galanter, editors, *Handbook of Mathematical Psychology*, volume 2. Wiley and Sons, New York.

Mehryar Mohri. 2002. Semiring frameworks and algorithms for shortest-distance problems. *Journal of Automata, Languages and Combinatorics* 7 (3):321–350.

Barbara H. Partee, Alice ter Meulen, and Robert E. Wall. 1990. *Mathematical Methods in Linguistics*. Kluwer, Dordrecht.

Geoffrey K. Pullum. 1986. Footloose and context-free. *Natural Language and Linguistic Theory* 4 (3):409–414.

Michael O. Rabin and Dana Scott. 1959. Finite automata and their decision problems. *IBM Journal of Research and Development* 3 (2):114–125.

James Rogers. 1997. Strict LT_2 : Regular : : Local : Recognizable. In Christian Retoré, editor, *Logical Aspects of Computational Linguistics: First International Conference, LACL '96 (Selected Papers)*, volume 1328 of *Lectures Notes in Computer Science/Lectures Notes in Artificial Intelligence*, pages 366–385. Springer.

William C. Rounds. 1970. Mappings and grammars on trees. *Mathematical Systems Theory* 4 (3):257–287.

Hiroyuki Seki, Takashi Matsumara, Mamoru Fujii, and Tadao Kasami. 1991. On multiple context-free grammars. *Theoretical Computer Science* 88:191–229.

Stuart M. Shieber. 1985. Evidence against the context-freeness of natural language. *Linguistics and Philosophy* 8:333–343.

Michael Sipser. 1997. *Introduction to the Theory of Computation*. PWS Publishing Company, Boston, MA.

Edward P. Stabler. 1997. Derivational minimalism. In Christian Retoré, editor, *Logical Aspects of Computational Linguistics*, volume 1328 of *LNCS*, pages 68–95, Berlin Heidelberg, Springer.

Edward P. Stabler. 2011. Computational perspectives on minimalism. In Cedric Boeckx, editor, *The Oxford Handbook of Linguistic Minimalism*. Oxford University Press, Oxford.

Edward P. Stabler. 2019. Three mathematical foundations for syntax. *Annual Review of Linguistics* 5:243–260.

J. W. Thatcher. 1967. Characterizing derivation trees of context-free grammars through a generalization of finite automata theory. *Journal of Computer and System Sciences* 1:317–322.

J. W. Thatcher. 1973. Tree automata: An informal survey. In A. V. Aho, editor, *Currents in the Theory of Computing*, pages 143–172. Prentice-Hall.

J. W. Thatcher and J. B. Wright. 1968. Generalized finite automata theory with an application to a decision problem of second-order logic. *Mathematical Systems Theory* 2 (1):57–81.

Rulon S. Wells. 1947. Immediate constituents. *Language* 23 (2):81–117.

Daniel H. Younger. 1967. Recognition and parsing of context-free languages in time n^3. *Information and Control* 10 (2):189–208.

6

Naturalism, Internalism, and Nativism: <What> The Legacy of *The Sound Pattern of English* <Should Be>

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6.1 Basics of *SPE* Phonology

Phonology is the study of abstract sound patterns in human *language*, as opposed to phonetics, which studies all aspects of *speech*, including articulation and acoustics. We illustrate with a somewhat simplified example. In Québec French, the adjective meaning 'small' shows an alternation between the tense vowel [i] in the open syllable of the masculine form *petit* [pt^{s}i] vs. the lax [ɪ] in the corresponding feminine form *petite* [pt^{s}ɪt], where the syllable is closed by the consonant [t], reflecting a general phonological pattern: [i] and [ɪ] are in complementary distribution determined by syllable structure. In English, the same phonetic vowels occur, with the same vocal tract configurations and corresponding sound spectra (*modulo* accidental details). However, the English vowels can appear in the same environment, say between a [b] and a [t] in a closed syllable, as in *beet* [bit] vs. *bit* [bɪt]. So, we can say that English and Québec French have the same two vowels **phonetically**, but the **phonological** status of [i] and [ɪ] differs in the two languages.

In *The Sound Pattern of English* (Chomsky and Halle 1968, henceforth *SPE*) and most phonological models, this difference consists of two factors, a representational difference and a computational difference:

- Québec French has the same vowel stored in the representations of *petit* and *petite*, say /i/, and a mental computation turns /i/ into [ɪ] in a closed syllable. The difference in pronunciation is a result of a specific computation.
- English has different vowels stored in the representations of *beet* and *bit*. The stored representational (featural) distinction persists in pronunciation.

The phonology of each language consists of various computations. In *SPE* the computations are called rules, and the phonology of a language is a complex function resulting from composing the rules in a particular order. The input to the phonology is called an

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underlying representation, and the output is called a surface representation or, somewhat confusingly, a "phonetic representation." The mapping of an underlying form to a surface form by the computational system is called a derivation. It is the output of the derivation, the "phonetic" form, that is the input to the mechanisms leading to speech, and this output form should not be confused with the actual articulatory movements and their concomitant acoustic results.

6.2 Internalism in Phonology

Our simple example from Québec French allows us to discuss one of the most important notions of *SPE* phonology, and Chomsky's linguistics more generally: radical internalism. The input representations referred to above consist of morphemes, minimal data structures containing (at least) semantic and phonological information. Under the internalist perspective, these morphemes are encoded as (or, just are) information in the minds/brains of speakers. They are not in books, in the air, or anywhere out in the world as properties of speech communities. When we informally refer to speakers of 'Québec French' or 'English' we assume an idealized population that is identical in all ways relevant to the phenomenon under discussion, say having type-identical vowels in type-identical morphemes in their lexicon.[1] So, the internalism that is standard in other aspects of Chomsky's linguistics, and is in fact the most profound consequence of the cognitive revolution of the 1950s and 1960s, is equally relevant to Chomsky's phonology.

According to the discussion on p. 3 of *SPE*, language is taken to be a system of knowledge that is fully internal to the human mind: "The person who has acquired knowledge of language has internalized a system of rules that determines sound-meaning connections for indefinitely many sentences." This "for the most part, obviously, unconscious knowledge," which is "realized physically in a finite human brain", is referred to as "the speaker-hearer's competence," and it should be strictly distinguished from "performance," that is, from "what the speaker-hearer actually does" with this knowledge on a particular occasion. The general goal of linguistics "is the construction of a grammar," where grammar refers to "the explicit theory constructed by the linguist and proposed as a description of the speaker's competence." Of course, competence cannot be observed directly. Its properties can only be discovered indirectly, for example by inferring them on the basis of evidence provided by performance. Since performance "is a complex matter that involves many factors," this main body of empirical data from which phonological conclusions can be drawn will necessarily include a welter of accidental and irrelevant information. A universal phonological theory provides a principled basis for distinguishing between relevant and irrelevant aspects of empirical data, as in all sciences.

Consistent with this internalism, we see that, just as in syntax, Chomsky's phonology, as presented in *SPE* itself and many of the papers leading up to the book (Chomsky 1951, 1957b,a, 1964b; Chomsky et al. 1956; Halle 1959, 1962, 1964; Chomsky and Halle 1965), considers the actual object of study to be the cognitive system (phonological competence) that underlies observable behavior (speech production and perception). Observable behavior is just one source of evidence for competence.

Despite the clarity and coherence of *SPE*'s radical cognitivism, much subsequent work in phonology has ignored or rejected internalism to varying degrees. As we'll see, much of the literature fails to engage with the philosophical foundations of the cognitive revolution, and has been preoccupied with describing verbal behavior, rather than the underlying knowledge that makes that behavior possible. These preoccupations have maintained or even gained in popularity from the time of the publication of *SPE* up until the present, as witnessed by the prominence of "output-driven" models of phonology (e.g., Tesar 2014) and by the prevalent orientation toward "the surface" throughout the field.

Of course, most scholars accept that *some* aspects of language are "in the mind," but the Chomskyan perspective is that language, phonology included, is *all* in the mind. Linguistic mental representations are the constituents of language, and are not understood as "representing" mind-external entities. For example, Chomsky (2009a, p. 27) proposes that for surface phonological (phonetic) entities "such as the syllable /ba/; every particular act externalizing this mental entity yields a mind-independent entity, but it is idle to seek a mind-independent construct that corresponds to the syllable." This perspective, not only for phonology, but also for syntax and semantics, is endorsed by many scholars, including Jackendoff (1992), who says "Language, as far as I can tell, is *all* construction," meaning "all internal construction."

Aside from internalism, naturalism and nativism are the most important notions of Chomsky's legacy in linguistics. These notions don't just apply to phonology as to syntax; rather it is also the case that Chomsky's consistent and radical versions of these notions can even be justified with phonological examples. As phonologists, we regret that the phonological arguments are not as well known as the syntactic ones. For the purposes of this brief discussion, we focus on the relationship between internalism and nativism.

6.3 Anti-Internalism and Rejection of Nativism

SPE is explicit in its commitment to nativism:

> The significant linguistic universals are those that must be assumed to be available to the child learning a language as an a priori, innate endowment. That there must be a rich system of a priori properties—of essential linguistic universals—is fairly obvious from the following empirical observations. Every normal child acquires an extremely intricate and abstract grammar, the properties of which are much underdetermined by the available data. This takes place with great speed, under conditions that are far from ideal, and there is little significant variation among children who may differ greatly in intelligence and experience. The search for essential linguistic universals is, in effect, the study of the a priori *faculté de langage* that makes language acquisition possible under the given conditions of time and access to data.
>
> It is useful to divide linguistic universals roughly into two categories. There are, first of all, certain "formal universals" that determine the structure of grammars and the form and organization of rules. In addition, there are "substantive universals"[2] that define the sets of elements that may figure in particular grammars. [p. 4]

Despite these clear statements, nativism has fared badly in the phonological literature in recent years, and we'll discuss two influential trends. Optimality Theory (OT) (e.g. Prince and Smolensky 1993; McCarthy and Prince 1993) began as a strongly nativist model of phonology, consisting of an innate constraint set, built on an inventory of substantive universals, such as the subsegmental features used in *SPE*. In OT, a universal algorithm determines the output form for a given phonological input based on a language-specific ranking. In OT, then, the only locus of language variation is in the ranking of the universal constraints in a given language *L* and the set of morphemes that happen to be present in the lexicon of *L* (although there is some confusion with respect to the latter issue, represented in discussion of the so-called Richness of the Base). For example, an underlying /i/ is able to surface in a closed syllable in English [bit] "beet," but not in Québec French [pt^{s}ɪt], despite the two languages having the same constraints, because the two differ in their constraint ranking.

The initially elegant OT model appeared to offer solutions to some longstanding issues, and introduced a set of different problems—a normal situation in discussion of incommensurable theories in any scientific field. However, it quickly became apparent that the innate component of phonology in OT terms was implausibly rich, requiring an *extensional* characterisation of a large set of constraints as part of innate endowment. More recently, the issue of nativism is just ignored in most OT literature, but has to be understood as tacitly rejected given the specificity of the constraints posited, such as "Assign one violation for each contrast between N and NC in which NC does not have an oral release that belongs to category of 4 or larger along the RELscale," which is an actually proposed constraint in a paper in the journal *Phonology* (Stanton 2019). In addition, various scholars posit constraints that are not just specific to one language, but to the realization of one morpheme in a particular language, such as the ALIGN-*um*-L markedness constraint that refers to the Tagalog morpheme /um/ (Kager 1999, p. 122).

Outside of the OT literature, we find anti-nativist titles such as *The emergence of distinctive features* (Mielke 2008) and "Phonology without universal grammar" (Archangeli and Pulleyblank 2015). How is it possible that Chomsky's stature in phonology is universally recognized by the phonological community, as is his development of the idea of Universal Grammar, and yet, so much current work, even by his former students, is anti-nativist, anti-UG? We think we have the answer, but first let's document (with added boldface) the not uncommon denial of nativism via the denial of the argument of the poverty of the stimulus (APoS) in the phonological literature.

Perhaps it is not surprising that a psychologist like Peter MacNeilage rejects the APoS:

Example 6.1 Peter MacNeilage, *The origin of speech (2008: 41):*

> however much **poverty of the stimulus** exists for language in general, **there is none of it** in the domain of the structure of words, the unit of communication I am most concerned with. **Infants hear all the words** they expect to produce. Thus, the main proving ground for **UG does not include phonology**.

This anti-nativist perspective is also implicitly anti-internalist since it suggests that words are out there for children to hear, a view at odds with the generative program as understood by, say, a syntactician like Howard Lasnik (2000, p. 3):

> The list of behaviors of which knowledge of language purportedly consists has to rely on notions like "utterance" and "word." But what is a word? What is an utterance? These notions are already quite abstract. Even more abstract is the notion "sentence." Chomsky has been and continues to be criticized for positing such abstract notions as transformations and structures, but the big leap is what everyone takes for granted. It's widely assumed that the big step is going from sentence to transformation, but this in fact isn't a significant leap. The big step is going from "noise" to "word."

MacNeilage's view also has an unfortunate English-centred perspective on words. In an agglutinative language like Turkish, a given root can appear in hundreds or thousands of words, such as the root *ev* "house" in the noun *evlerimizdekilerinki* meaning "the one belonging to the ones in our houses" (Hankamer 1989, p. 397). Children clearly do not hear all the words that they can produce.

Phonologist Jeff Mielke's work arguing against an innate set of phonological features also rejects APoS:

Example 6.2 Mielke (2008), *The Emergence of Distinctive Features*

- "Many of the **arguments for UG in other domains do not hold for phonology**. For example, there is little evidence of a learnability problem in phonology." [p. 33]
- [Most of the evidence for] "**UG is not related to phonology**, and phonology has more of a guilt-by-association status with respect to innateness." [p. 34]

Although Mielke dedicates a whole monograph to arguing that features can be learned, he never addresses logical arguments against such a view presented by Fodor (1980) and others, or the clear assertion by Chomsky and Halle (1965) that "one does not 'construct features from scratch for each language'" in a response to the American Structuralist linguist Fred Householder (1965).

In a discussion of Chomsky's legacy, it is most relevant to note the divergent perspectives on such matters of phonologists who have worked in the generative tradition:

Example 6.3 Archangeli and Pulleyblank (2015) "Phonology without universal grammar"

- "See Mielke [2004/8] on why **features cannot be innately defined**, but must be learned"
- "[Children face] the challenge of **isolating specific sounds from the sound stream**"
- "the predictions of [Emergent Grammar] fit the data better than do the predictions of UG."

Example 6.4 Blevins (2003, p. 235), *Evolutionary Phonology*

> "**Within the domain of sounds, there is no poverty of the stimulus**. [I offer] general arguments against the 'poverty of stimulus' in phonology, … [there is no evidence that] regular phonological alternations cannot be acquired on the basis of generalizations **gleaned directly from auditory input**."

These passages clearly locate segments in the auditory input, the "sound stream," and thus reject the radical rationalist-internalist perspective of Chomskyan phonology

alluded to above, simply expressed by Hammarberg (1976, 354): "[I]t should be perfectly obvious by now that segments do not exist outside the human mind." Scholars denying a poverty of the stimulus problem for phonology fail to recognize the well-established difficulty of defining invariant acoustic correlates of segments, a challenge known as the Problem of the Lack of Invariance, which is discussed insightfully by philosopher Irene Appelbaum (1996).

Finally, here is yet another phonologist, author of a popular text and co-editor of a philosophically oriented volume on phonological knowledge (Burton-Roberts et al. 2000) rejecting phonological internalism and nativism in one breath:

Example 6.5 Carr (2006), "Universal grammar and syntax/phonology parallelisms"

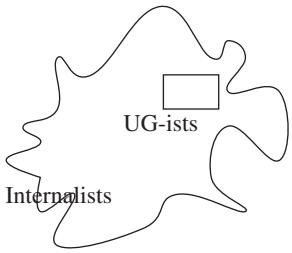
"Phonological objects and relations are internalisable: **there is no poverty of the stimulus argument in phonology. No phonological knowledge is given by UG**."

Carr's quotation makes clear the logical relationship between internalism and nativism, and helps us to explain the rejection of nativism as a logical consequence of a failure to appreciate internalism: if phonology is internalisable, it need not be innate. A non-Chomskyan linguist or psychologist studies the mind, and so is an internalist, but he or she may very well deny any interesting domain-specific innate knowledge—think of your average connectionist. So, internalism definitely does not imply nativism. However, there is a valid implication in the other direction: Universal Grammar is a claim of innate knowledge, so a nativist in cognitive science has to be an internalist. By contraposition we know that if "nativism implies internalism" is true, then "Not-internalism implies Not-nativism" is also true. And that's the problem: For many phonologists, it is logically impossible that they be nativists, because they are not internalists.

Example 6.6 The relationship between internalism and nativism:

- Internalism $\not\Rightarrow$ UG
- UG $\Rightarrow$ Internalism

$\therefore$ No-Internalism $\Rightarrow$ No-UG



So, given the rejection of the internalist legacy of *SPE*, the nativist legacy stands no chance. This anti-internalism is clear from claims in phonology, phonological acquisition, and speech perception literature that features, segments, alternations, patterns and so on are *in* the signal, to be *found* by the listener / learner. We know, however, that just as a Necker cube is not discovered by our visual faculty, but instead is invented by the mind each time it is perceived or imagined (Marr 1982), in the same way, the

mind constructs phonological representations out of a limited set of innately available resources such as features. We even see this happening when we interpret the sounds of a parrot or Hoover the "talking" seal as speech—the words and segments we "hear" are definitely not out in the world.

6.4 What Is Innate?

SPE phonology explicitly adopts strict and consistent naturalism, internalism and nativism. We have indicated that much recent work rejects without justification the nativism of *SPE*. However, another rampant problem in the literature is an over-eager implausible nativism, deriving, we believe, from a misreading of *SPE*. This work, based on the vague notion of markedness, is portrayed as a development of a passage in *SPE* itself:

> The problem is that our approach to features, to rules and to evaluation has been overly formal. Suppose, for example, that we were systematically to interchange features or to replace [αF] by [-αF] (where α is +, and F is a feature) throughout our description of English structure. There is nothing in our account of linguistic theory to indicate that the result would be the description of a system that violates certain principles governing human languages. To the extent that this is true, we have failed to formulate the principles of linguistic theory, of universal grammar, in a satisfactory manner. In particular, we have not made use of the fact that the features have intrinsic content. [p. 400]

Unfortunately, the literature on markedness ignores a later passage where Chomsky and Halle acknowledge that a formal model of phonological computation should probably not make reference to "intrinsic content" of features:

> It does not seem likely that an elaboration of the theory along the lines just reviewed will allow us to dispense with phonological processes that change features fairly freely. The second stage of the Velar Softening Rule of English (40) and of the Second Velar Palatalization of Slavic strongly suggests that the phonological component requires wide latitude in the freedom to change features, along the lines of the rules discussed in the body of this book.[p. 428]

So, Chomsky and Halle conclude that the computational system that makes up the phonological module cannot be understood by reference to functional considerations of naturalness or restrictions on surface forms. This conclusion is echoed elsewhere: "Where properties of language can be explained on such 'functional' grounds, they provide no revealing insight into the nature of mind. Precisely because the explanations proposed here are 'formal explanations,' precisely because the proposed principles are not essential or even natural properties of any imaginable language, they provide a revealing mirror of the mind (if correct)" (Chomsky 1971, p. 44).

If we agree with Chomsky (2007) that "the less attributed to genetic information (in our case, the topic of UG) for determining the development of an organism, the more feasible the study of its evolution," then not only the highly specific constraints mentioned above, for particular morphemes in particular languages, but pretty much every putative expression of ill-formedness or markedness, needs to be banished from theorizing about UG.

Our own interpretation of the legacy of *SPE* includes the following components:

(i) We assume that phonological UG contains innate features, and that this assumption is in line with what was referred to in *SPE* as "universal phonetics," including a set of substantive features that are "independent of any particular language" and that determine "a certain infinite class of possible phonetic representations from which the phonetic forms of sentences of any human language are drawn" (*SPE*, p. 8). Despite the disrepute into which the universal phonetics view has fallen, we believe that the arguments given in *SPE* and Chomsky and Halle (1965), remain convincing.

(ii) Possibly some other representational primitives or structure-building algorithms to account for syllables, feet, stress, and other phenomena that we assume are also part of phonological UG.

(iii) Some basic logical operations that define the mappings among the representations. This part of the model can be called a theory of structural changes for the rules in a derivation. In our own recent work (e.g., Leduc et al. Forthcoming; Bale and Reiss 2018), we have deconstructed the traditional *SPE* arrow → and replaced it with set subtraction and unification for a wide range of processes.

(iv) A theory of environments that determines the conditions under which one part of a representation can trigger a nonvacuous mapping to another representation in a derivation. For example, there appear to be rules in which a consonantal change in a syllable onset is triggered by a consonant in the immediately preceding onset. Could a rule be triggered by any preceding onset at any distance? Many scholars have worked on such questions about locality in phonology. Our own prejudice is that actual segmental adjacency, which is the most typical condition in rules is just a special case of long-distance interaction.

(v) Closely linked to the innateness of features as components of a universal representational code, is the notion, accepted in *SPE*, of a *universal phonetic interpretation* of features (and other representational primitives). In addition to participating in phonological representation and computation, features also serve as the basis for phonetic interpretation at the interface between linguistic competence and the sensory-motor system: "the distinctive features provide a representation of an utterance which can be interpreted as a set of instructions to the physical articulatory system, or as a refined level of perceptual representation" (p. 65).[3] This no longer falls under the purview of phonology, and so *SPE* provides only cursory remarks about the interpretation of features in speech production or perception, suggesting that it is governed by "universal interpretative conventions" (p. 403). In other words, the output of the grammar, the surface or "phonetic" representation, is transduced to speech output in an invariant manner, not specific to any particular language. This position is either ignored or presented as patently false by much recent work, but a full defense is not possible here (see Volenec and Reiss (2018) for details).

The issue arises when putatively identical featural representations (using pretty much any current model of phonological primes) are said to have different pronunciations in different languages. To make this concrete, recall our discussion of the vowels [i] and [ɪ] in English and Québec French. In fact, the [i] of *petit* and the [i] of *beet* are somewhat different. The universal phonetics perspective of *SPE* requires that the two vowels in fact be phonologically different, encoded differently

in long-term memory. The rejected alternative (adopted by most other work) is that the two can be (type)-identical but realized differently by post-phonological language-specific rules of phonetic implementation.

6.5 Naturalism in Phonology

The rightful legacy of *SPE* includes the naturalism, internalism and nativism found also in Chomsky's syntactic work.[4] By naturalism, we refer to the idea that language, including phonology, can fruitfully be studied as a natural object (see especially Chomsky 2000). Chomsky has labeled the resistance to naturalistic inquiry of language among certain philosophers "methodological dualism." As James McGilvray sums up the idea in the introduction to Chomsky (2009b), certain philosophers "might have anything from a reasonably clear to a very good […] idea of what naturalistic scientific methodology is, but they clearly refuse to hold that language and concepts could be investigated using this methodology" (p. 22) and "when it comes to crucial features of the mind, the empiricists abandon not just internalism and nativism, but the methods of the natural sciences" (p. 21).

We detect a related methodological problem within contemporary phonology which also seems tied to neglect and/or ignorance of foundational arguments concerning internalism and nativism. Phonology has seen a number of widely adopted innovations in recent decades, such as the use of more complex graph-theoretic representations for both segment-feature relations (e.g., Sagey 1986) and higher-order units like syllables (e.g., Zec 2007), that are consistent with a trend towards increased rigor and explicitness expected in science. However, phonology has a long way to go before it can be considered a mature science in practice. The rejection of radical internalism has lead to the biggest problem that characterizes much of phonological reasoning since *SPE*, the notion of markedness, which results in forms of teleological reasoning that, we hold, have no place in modern scientific inquiry. Markedness-based empiricist phonological theories are trying to be theories about too many things at the same time—not only phonological competence, but also typological trends concerning the distribution of patterns in the languages of the world; verbal behavior factors related to speech rate; inter- and intra-speaker variation related to dialect and register differences; and even the intelligibility of the speech of young children.[5] In trying to do too much, such work fails to adopt the normal strategies of natural sciences like isolation, idealization and simplification.

Probably a majority of working phonologists believe that "Many if not most phonological phenomena [are] characterizable in terms of output restrictions" (Tesar 2014), or else that phonological grammars manifest "conspiracies" for "reoccurrence of a common output factor" as Kager's (1999, p. 56) OT discussion summarizes Kisseberth's (1970) early post-*SPE* work. McCarthy's (2011, p. 2) discussion of Kisseberth asserts that a conspiracy involving two rules ensures that "[f]inal vowel deletion cannot create bad syllables in surface forms, and epenthesis exists to eliminate" bad syllables. In some work, the purpose is expressed in terms of pathologies: phonological computation has to "cure" a "condition" (Yip 1988). Phonology is said to contain "principles of well-formedness (the laws) that drive it" (Prince and Smolensky 1993, p. 216), taking input representations and making them somehow better, more harmonic or optimal. Such passages, demonstrate that phonology has not, in general, achieved the rigor of

a natural science—naturalism is not explicitly rejected, but such teleological rhetoric makes it clear that it hasn't been universally embraced either.

Markedness and other expressions of "surface-orientation" in phonology are reminiscent of Appelbaum's (1996) critique of the protean reference to "gesture" in the motor theory of speech perception (e.g. Liberman and Mattingly 1985) and Articulatory Phonology (Browman and Goldstein 1989): "By leaving the referent of 'phonetic gestures' ambiguous between an articulatory interpretation and a neural one, proponents of the motor theory try to exploit the theoretical benefit of each interpretation, without incurring the theoretical burden of either." In a similar vein, surface-oriented, output-driven phonology oscillates between actual phonetics (sound and articulation) and the output of the grammar (surface phonetic representations). For example, McCarthy and Prince (1995, p. 88) refer to an OT constraint as the "phonologization of Boyle's law."[6] There is no way that Boyle's law, or the Bernoulli effect or details about tongue and lip position of actual articulation can *motivate* the computation between input and output *of the grammar*. Yet this is exactly what the copious work in OT, Natural Phonology, and various repair-based models of phonology proposes. If grammar is internal, then external facts like the behavior of gases under pressure or the properties of the muscles controlling the lips, are *not directly available to the grammar* (although they may play some role in filtering the kinds of data that learners can have access to).

For a particularly egregious abuse of phonetic motivation, consider the parameterized constraints of McCarthy (1996, p. 223), e.g. "the meaning of this constraint is this: the constraint is violated if a surface stop, or its underlying correspondent is immediately preceded by a vowel." In other words, phonetic (articulatory or acoustic) motivation is supposed to explain bans on *potential* sequences of segments across levels of representation: a stop consonant should not appear in a surface representation if its correspondent in the underlying representation is preceded by a vowel. In contrast to this approach referring to marked or banned potential structures, *SPE* handles such phenomena by treating a language's phonology as a function composed of multiple rules. As in mathematics and logic, the order of composition matters. There are no teleological conspiracies to repair, cure or optimize representations; no attempts by the grammar to facilitate articulation or comprehension according to vague claims about the "communicative function" of language (see papers in Hayes et al. 2004, for examples of this view). In the *SPE* tradition, grammar models "dumb," mechanical computation—that's a good thing, since *grammars* don't have goals and desires, even if *people* do. The *SPE* arguments given *against* building markedness into the formal theory are consistent with the idea of phonology as naturalistic inquiry, and these convincing arguments are only reinforced by the inconsistencies in markedness-based approaches.

6.6 Conclusion

Zenon Pylyshyn (1984, p. xix) suggests that "the kinds of theories cognitive scientists entertain are intimately related to the set of tacit assumptions they make about the very foundations of the field of cognitive science. In cognitive science the gap between metatheory and practice is extremely narrow." As elsewhere, Chomsky's work revolutionized the foundations of phonology, yet the implications of *SPE* and related work have been neglected, to the detriment of the field. This is consistent with the failure of

phonologists to accord enough weight to clear, accessible arguments made by scholars like Fodor, Jackendoff, and even Kant, relating to leading ideas of Chomsky's general philosophical outlook. Beyond phonology, philosophers and psychologists, as well as syntacticians and semanticists interested in "big picture" issues like naturalism, internalism and nativism, would be well served by paying more attention to the achievements of *SPE*. Working in the field, we remain enthusiastic about discovering not only how these leading ideas apply in phonology, but also how new phonological arguments can bolster Chomsky's often radical, broad philosophical stands.

Endnotes

1 Crucially, when linguists discuss small scale variation, they make a more fine grained generalization and talk about dialects, even regiolects, with the exact same logic, just a different "zoom factor."
2 The term *substantive* here means "having substantive (phonetic, speech-related) *correlates*," not "being substance"—an important distinction often misinterpreted in the phonological literature.
3 Passages like this understandably lead Rey (2003) to the contention that linguists, including Chomsky, actually are intentionalist when they are not being philosophical.
4 We discuss many of the themes covered here in greater detail elsewhere (Hale and Reiss 2008; Bale and Reiss 2018; Volenec and Reiss 2018, 2020; Reiss 2017).
5 In our view, this field of "child phonology" has nothing to do with competence grammars, and everything to do with children's immature performance systems (Chomsky 1964a; Smith 2010; Hale and Reiss 1998, 2008).
6 McCarthy and Prince (1995, p. 88) "claim that the operative constraint here is a requirement that posterior stops (i.e., velars) be voiceless—to be referred to as POSTVCLS. This constraint phonologizes the familiar articulatory effect of Boyle's law: it is difficult to maintain voicing when the supraglottal cavity is small."

References

Appelbaum, Irene. The lack of invariance problem and the goal of speech perception. In *The 4th International Conference on Spoken Language Processing*, pages 1541–1544, 1996.

Archangeli, Diana, and Pulleyblank, Douglas. Phonology without universal grammar. *Frontiers in Psychology*, 6, 2015.

Bale, Alan, and Reiss, Charles. *Phonology: A formal introduction*. MIT Press, Cambridge, MA, 2018.

Blevins, Juliette. *Evolutionary Phonology: The Emergence of Sound Patterns*. Cambridge University Press, Cambridge, MA, 2003.

Browman, Catherine P., and Goldstein, Louis. Articulatory gestures as phonological units. *Phonology*, 6(2):201–251, 1989.

Burton-Roberts, Noel, Carr, Philip, and Docherty, Gerard. *Phonological Knowledge: Conceptual and Empirical Issues*. Oxford University Press, Oxford, 2000.

Carr, Philip. Universal grammar and syntax/phonology parallelisms. *Lingua*, 116(5):634–656, 2006.

Chomsky, Noam. Morphophonemics of Modern Hebrew. *Philadelphia: University of Pennsylvania MA thesis.[Facsimile printing of original typescript, New York: Garland, 1979.]*, 1951.

Chomsky, Noam. Review of Jakobson-Halle, 1956. *International Journal of American Linguistics*, 23:234–242, 1957a.

Chomsky, Noam. Review of C. F. Hockett *A Manual of Phonology*. *International Journal of American Linguistics*, 23:223–234, 1957b.

Chomsky, Noam. Formal discussion in response to W. Miller and S. Ervin. In Ursula Bellugi and Roger Brown, editors, *The Acquisition of Language*, pages 35–39, Chicago, 1964a. University of Chicago Press.

Chomsky, Noam. *Current issues in linguistic theory*. Mouton & Company, 1964b.

Chomsky, Noam. *Problems of knowledge and freedom: the Russell lectures*. Vintage Books, New York, 1971.

Chomsky, Noam. Language as a natural object. In *New horizons in the study of language and mind*, pages 106–133. Cambridge University Press, Cambridge, MA, 2000.

Chomsky, Noam. Approaching UG from below. In Uli Sauerland and Hans-Martin Gärtner, editors, *Interfaces + recursion = language?: Chomsky's minimalism and the view from syntax-semantics*, pages 1–24. Mouton de Gruyter, Berlin, 2007.

Chomsky, Noam. Opening remarks and conclusion. In Massimo Piattelli-Palmarini, Pello Salaburu, and Juan Uriagereka, editors, *Of minds and language: a dialogue with Noam Chomsky in the Basque country*. Oxford University Press, Oxford, 2009a.

Chomsky, Noam. *Cartesian linguistics: A chapter in the history of rationalist thought*. Cambridge University Press, 3rd ed edition, 2009b.

Chomsky, Noam and Halle, Morris. Some controversial questions in phonological theory. *Journal of Linguistics*, 1: 97–138, 10 1965.

Chomsky, Noam and Halle, Morris. *The Sound Pattern of English*. Harper & Row, New York, 1968.

Chomsky, Noam, Halle, Morris, and Lukoff, Fred. On accent and juncture in English. *For Roman Jakobson*, pages 65–80, 1956.

Fodor, Jerry. On the impossibility of acquiring "more powerful" structures. In M. Piatelli-Palmarini, editor, *Language Learning: The debate between Jean Piaget and Noam Chomsky*, pages 142–162. Harvard University Press, 1980.

Hale, Mark, and Reiss, Charles. Formal and empirical arguments concerning language acquisition. *Linguistic Inquiry*, 29:656–683, 1998.

Hale, Mark, and Reiss, Charles. *The Phonological Enterprise*. Oxford University Press, Oxford, 2008.

Halle, Morris. *The Sound Pattern of Russian.* Mouton & Company, The Hague, 1959.

Halle, Morris. Phonology in generative grammar. *Word*, 18(1-3):54–72, 1962.

Halle, Morris. On the bases of phonology. In Jerrold J. Katz and Jerry Fodor, editors, *The structure of language*, chapter 9, pages 324–333. Prentice-Hall, Englewood Cliffs, NJ, 1964.

Hammarberg, Robert. The metaphysics of coarticulation. *Journal of Phonetics*, 4:353–363, 1976.

Hayes, Bruce, Kirchner, Robert Martin, and Steriade, Donca. *Phonetically based phonology*. Cambridge University Press, Cambridge, 2004.

Householder, Fred W. On some recent claims in phonological theory. *Journal of linguistics*, 1(1):13–34, 1965.

Jackendoff, Ray. The problem of reality. In *Languages of the mind : essays on mental representation*, pages 157–176. MIT Press, 1992.

Kager, René. *Optimality Theory*. Cambridge University Press, Cambridge, 1999.

Kisseberth, Charles W. On the functional unity of phonological rules. *Linguistic Inquiry*, 1(3):291–306, 1970.

Leduc, Marjorie, Reiss, Charles, and Volenec, Veno. Votic vowel harmony in Substance Free Logical Phonology. In *Oxford Handbook of vowel harmony*. Oxford University Press, Oxford, Forthcoming.

Liberman, Alvin M., and Mattingly, Ignatius G. The motor theory of speech perception revised. *Cognition*, 21(1):1–36, 1985.

Marr, David. *Vision: a computational investigation into the human representation and processing of visual information*. W.H. Freeman, San Francisco, 1982.

McCarthy, John. Remarks on phonological opacity in optimality theory. In J. Lecarme, J. Lowenstamm, and U. Shlonsky, editors, *Studies in Afroasiatic Grammar: Papers from the Second Conference on Afroasiatic Linguistics, Sophia Antipolis, 1994*, pages 215–243. Holland Academic Graphics, The Hague, 1996.

McCarthy, John, and Prince, Alan. Prosodic Morphology I: Constraint interaction and satisfaction. *Technical Report# 3, Rutgers University Center for Cognitive Science*, 1993.

McCarthy, John, and Prince, Alan. Faithfulness and reduplicative identity. In Jill Beckman, Laura Walsh Dickey, and Suzanne Urbancyk, editors, *University of Massachusetts Occasional Papers in Linguistics, Vol. 18*, pages 249–384. GLSA, University of Massachusetts at Amherst, Amhert, MA, 1995.

McCarthy, John J. *Doing optimality theory: Applying theory to data*. John Wiley & Sons, 2011.

Mielke, Jeffrey. *The emergence of distinctive features*. Oxford University Press, Oxford, 2008.

Prince, Alan, and Smolensky, Paul. *Optimality Theory: Constraint Interaction in Generative Grammar (Technical Report)*. Rutgers Center for Cognitive Science, New Brunswick, NJ, 1993.

Pylyshyn, Zenon. *Computation and cognition: Toward a foundation for cognitive science*. MIT Press, Cambridge, MA, 1984. ISBN 0262160986.

Reiss, Charles. Substance Free Phonology. In S.J. Hannahs and Anna Bosch, editors, *Handbook of Phonological Theory*, pages 425–452. Routledge, New York, 2017.

Rey, Georges. Intentional Content and a Chomskian Linguistics. In Alex Barber, editor, *Epistemology of Language*, pages 140–186. Oxford University Press, 2003.

Sagey, Elizabeth Caroline. *The representation of features and relations in non-linear phonology*. PhD thesis, Massachusetts Institute of Technology, 1986.

Smith, Neil. *Acquiring phonology: a cross-generational case-study*. Cambridge University Press, 2010.

Stanton, Juliet. Constraints on contrast motivate nasal cluster dissimilation. *Phonology*, 36(4):655–694, 2019.

Tesar, Bruce. *Output-driven phonology: Theory and learning*. Cambridge University Press, 2014.

Volenec, Veno, and Reiss, Charles. Cognitive Phonetics: The transduction of distinctive features at the phonology-phonetics interface. *Biolinguistics*, 11, 2018.

Volenec, Veno, and Reiss, Charles. Formal Generative Phonology. *Radical: A Journal of Phonology*, 2020.

Yip, Moira. The Obligatory Contour Principle and phonological rules: A loss of identity. *Linguistic Inquiry*, 19:65–100, 1988.

Zec, Draga. The syllable. In Paul de Lacy, editor, *The Cambridge handbook of phonology*. pages 161-194. Cambridge University Press, 2007.

7

Language as a Branch of Psychology: Chomsky and Cognitive Science[1]

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Editors' note: Lila Gleitman studied with Zellig Harris in the 1950s, shortly after Chomsky did, and then over the decades since has been a leading proponent of Chomsky's views in psychology, training many of its leading researchers in the field. Her work has been so important and influential in the development of those views there that she was the first person the editors of this volume turned to provide a perspective on that development.

Most of this chapter has been extracted from an article by Professors Gleitman, Mark Y. Liberman, Cynthia A. McLemore, and Barbara H. Partee, "The Impossibility of Language Acquisition (and How They Do It)," which appeared in the *Annual Review of Linguistics* 2019, 5:17.1–17.24 (online at clinguist.annualreviews.org). Those authors own the copyright, but have granted permission to the present editors to reproduce the portions included here.

Both that article and the present one consist of an autobiographical interview with Professor Gleitman: the style and first-person voice throughout is hers, and the occasional interpolations in square-brackets are those of her and the other authors (additions and interpolations in curly brackets are those of the present editors). The three opening paragraphs below and a new section 10 have been added by Professor Gleitman (Section 11 is the original's Section 10). To keep within the word limits, we have omitted the earlier article's Sections 5–9, except for their titles. Professor Gleitman especially thanks Cynthia McLemore, Sharon Armstong, Claire Gleitman, and Mark Liberman, whose aid was crucial in organizing the new material presented here.

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Noam Chomsky, almost single-handedly, exposed the bankruptcy of radical Behaviorism and its learning theoretic handmaiden, passive associationism, as the explanatory basis

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for human language learning and knowledge; for the opening discussion in this regard, see his {1959} "Review of Skinner's Verbal Behavior," which appeared in the journal *Language*.

Initially, my own vague presupposition about language learning, in common with most scientists as well as laypersons of that time, was that language learning is at bottom an outside-in procedure, a more or less straightforward function from what is heard to what is known. After all, exposed to English, the English learn English, and exposed to French, the French learn French. This truism accepted, the question remains how the young human mind records, manipulates, and organizes this database. Chomsky's insistence on understanding the class of problems here has played a major role in the emergence of the field now known as Cognitive Science.

Excerpted below is a section of an autobiographical description of the factors that led me from initial empiricist leanings to Chomsky's position emphasizing language as the pinnacle of human cognitive competence.

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This autobiographical article, which began as an interview, reports some reflections by Lila Gleitman on the development of her thinking and her research – in concert with a host of esteemed collaborators over the years – on issues of language and mind, focusing on how language is acquired. Gleitman entered the field of linguistics as a student of Zellig Harris, and learned firsthand of Noam Chomsky's early work. She chose the psychological perspective, later helping to found the field of cognitive science; and with her husband and long-term collaborator, Henry Gleitman, for over 50 years fostered a continuing research community aimed at answering questions such as: When language input to the child is restricted, what is left to explain language acquisition? The studies reported here find that argument structure encoded in the syntax is key ("syntactic bootstrapping") and that children learn word meaning in epiphanies ("propose, but verify").

7.1 Background

7.1.1 Graduate School

From the beginning of my graduate school days I was exposed to the best of the best among linguists: Zellig Harris and his greatest student, Noam Chomsky, who had just moved to MIT when we met. They represent, at least to my understanding, two opposed trends in the study of language and its learner-users. Harris was the pinnacle of structuralists, {believing} that what you saw (rather: heard) was what you got, and to my mind is the father of "big data" analysis as it appears in the current computational and psychological literature. For him, the sole legitimate approach was relative-distributional analysis, and his theoretical aim, in these terms, was to find mechanical procedures that moved theory from phoneme to morpheme, thence to phrase, thence to sentence, and finally to connected discourse (Harris 1951, 1952).

One obstacle to identifying principles of coherent discourse was that sentences with the same information content could have very different syntactic structures. {Chomsky's} big step toward a solution was to render all sentences in a normal or "kernel" form, removing optional variations in form and style while preserving content. The relations by which one could get to the kernel forms of sentences were what

was first known as "transformations." One might think of this bottom-up analysis as a proposal about how language acquisition works. That's how I understood it, but certainly and emphatically not how Harris {did}. He disdained "psychologizing" and meant to describe "language," rather than the activities or acquirers of such a system.

In my first year of graduate school with Harris, I concretized my own idiosyncratic understanding of the Harrisian point of view in a game – perhaps, more correctly, an evangelical demonstration – which I called The Great Verb Game. It was designed to show that one could recover a specific verb, or small cluster, just from an enumeration of the surface structures in which it appeared. I would think up some "mystery verb" and write it down, covering it. The "players" were to guess it from hearing, essentially, subcategorization frames. So, after a little instruction, the player hears/sees the frame N1 V N2 from N3 and is to come up with an example (say, *take*: *John took candy from the baby*). Next the player was offered another such frame, understood to be a paraphrase or entailment of the first, maybe N1 V N3 from N2. Notice that *take* will not work in this second case (*John took the baby from the candy*); it won't preserve meaning or might even be ungrammatical. So the player revises her guess. After a couple more clue frames, such as N2 V from N3, and N1 V N2 and N3 (and if the players are smart undergraduates or other verbal whizzes), they come up with the (or a) verb that survives this winnowing-down procedure (in the present case, *separate*). Turning over my card, I now triumphantly show them "my" verb, hoping to convince them that the meanings are embedded in the structure in some way. In my first year or two as Harris's graduate student, I tried to formalize these ideas in terms of some derivational web ("chains of Harrisian transformations"), but this turned out to be a false step. In later years, however, these ill-formulated but interesting ideas returned to me in the context of studies in word-meaning acquisition, as I'll mention. But in my first years, this bit of verbal legerdemain so amused audiences that I think this is what caused Swarthmore College to give me my first job.

For the most part, though, my views were rapidly changing because of contact with, and reading of, Noam Chomsky (Chomsky 1957, 1959, 1965). His thinking and findings began to suggest to me, and to a large following of younger scholars who began to surround him, that these surface sentences at the core of Harris's thinking were mere artifacts of an underlying innate system that was only indirectly reflected in our everyday speech forms. Even more importantly, I became convinced of that approach, bolstered by the preliminary findings emerging from my (and collaborators') earliest studies of language in infants and young children. From an autobiographical point of view, I was dragged kicking and screaming toward Chomsky's view, which offended my innately empiricist leanings. Anyhow, I'll now try to say something about the work I did with many brilliant younger collaborators and where it has led me over the years.

7.1.2 What Do They Know and When Do They Know It?

Few, if any, humans behave like the ideal grammarians that these theories – even Harris's – purport to describe. First there is the question of what babies and toddlers "know" about language despite being unable to understand or produce much of the speech to which they are being exposed. The psychological literature, as it looked when I first examined it, described at most what children actually produced, as a function of age: so and so many words at age one, more at age two, and so forth; one-word utterances at first ("Momma") and two at a time later on ("Mommy sock"). In the early

sixties, with the advent of Chomsky's first writings on the psychology of language, psychologists began to write little "grammars" of the child's primitive speech (see, e.g. Brown et al. 1968; Rodd and Braine 1971). But what is the status of these descriptions? Is children's speech, thus chronicled and organized, a reasonable proxy for what they know about their language – or about Language?

With Elizabeth Shipley, my brilliant colleague in mathematical psychology, I set out to probe the toddlers further, asking them, in effect, "Is the following sentence grammatical in your infant dialect?" To be clearer, we tried to find out if *Mommy sock* was an output fairly representing their linguistic knowledge at time of test. After all, when linguists try to build grammars, they never simply use actual speech as the data, but rather, or in addition, use direct or indirect judgments of grammaticality, aiming to get at what constitutes "your language," discarding speech errors, and so forth.

Our finding, in brief (Shipley et al. 1969), was that every kid who spoke in two-word sentences like *Throw ball* acted as if the same two-word sentences from the mother to them were abnormal – they didn't obey those commands, but acted as if something bizarre had happened, whereas grammatical sentences like *Throw me the ball*, they simply obeyed.

This raises a second question. It may be [and Henry Gleitman and I showed, at some length (Gleitman and Gleitman 1979)] that you can't get these judgments in any coherent or full way from even the mature speakers who, if anybody, are the targets that the theory of grammar is, or should be, designed to organize and explain. Most people can't even tell you how *black birdhouse*, *blackbird house*, and *house bird-black* differ in their meaning (that is, in the paraphrases they license). A question we raised concerned how a grammar built from judgments of one population – let us say, literary or otherwise book-wise speakers of some standard dialect – can be used as the empirical basis for building a theory of all native users. Well, we did convince ourselves, in the end, that judgment-giving itself, while useful if available, was not the only relevant source of data.

Yet a variety of uses of language, many of them important, are well correlated with the ability to give linguistic judgments – that is, to contemplate language more or less explicitly, even consciously. As we later showed with several other collaborators, including Paul Rozin and Kathy Hirsh-Pasek (Gleitman and Rozin 1977; Hirsh-Pasek et al. 1978), there is a cluster of skills including learning (or inventing!) an alphabetic writing system, making and understanding puns, and the like that are predicted by this "metalinguistic awareness" (Gleitman and Gleitman 1979). Something like these early generalizations is reminiscent of recent studies and approaches now called executive function, which also attempt to describe and explain certain users' access to aspects of their own cognitive functioning.

7.2 A First Look at the Input to the Child: Non-Effects of Motherese

Now we move to the story of what I did in language acquisition, with a succession of brilliant colleagues. Many of them were called students at first, but they never were. They were just younger colleagues.

Penn's psychology department hired me in 1971, even though I had never taken a class in psychology. So I became a member of this excellent department, full of really smart people doing smart things on perception and learning and memory, and also being properly skeptical of linguistics, which I mention because there's much to be said

for contact with such "outsiders" for keeping one thoughtful. I still have a visual picture in my mind of the great learning psychologist Bob Rescorla smirking politely at my more overwrought convictions about the nature of language and what we know.

After convincing myself that people know more than they can necessarily say, I still was extremely skeptical of Noam's idealization of a homogeneous speech community – sort of – which came out of that previous work that I did. And the claim that language was innate I couldn't even make out; what could that possibly mean? So I was not only an empiricist at heart, but one of my frequent sayings has always been "Empiricism is innate."

And it certainly was with me. I'd say, What are you talking about? If you're in France, you learn French. If you're in England, you learn English. There's a sense in which it's totally obvious that language is learned from a very precise data set – sentences of English or sentences of French. Language learning comes from the outside in. But it's just as obvious that it's also from the inside out, because many of the cats and the dogs in the house are exposed to the same data set, and notoriously none of them learn English.

So if you're going to study language acquisition, a minimum first step is to distinguish between what's coming from the outside and what may be coming from the inside. An obvious way to do that is to look at what input a child receives. It's not a random sample of English sentences. Does it matter what you hear? Well, obviously, but *how* does it matter what you hear?

But because all my intuitions are wrong [laughter] – you know, I always start out in the wrong place. And Noam was on about how you go over to Europe on a sabbatical and your kids learn the new language and you don't, so there's something about being a child. And I thought, no, there's something about going to kindergarten and hearing kindergarten sentences instead of hearing learned sentences about linguistics.

With my colleagues, starting with Elissa Newport, we began to look at input. People were already saying that mothers speak a special kind of simplified language to their children, and that's what accounts for the learning.

Henry humorously entitled that kind of language "motherese." [Barbara: He invented the term?] He invented the term. And Elissa Newport, for her dissertation work, began to ask if this "teaching language" really existed in the average home and what, if any, were its effects on infant learning (Newport 1975). Newport, even as a beginning graduate student, had the clearest vision of how to study, and evaluate, the effects of input variation on the acquisition function. In later years she went on to study the effects of these external influences in unusual and, therefore, revealing circumstances, including second language learning, late learning of a first language (as in some isolated deaf populations), and then how stripped-down artificial languages are used to reveal certain universal or particular properties. More recently she's been responsible for a renaissance of thinking about brain damage and the "critical period" for language learning. Not incidentally, she became my lifelong friend. But back to her first, graduate-school, studies of input and learning – that is, the "inside-out" effects.

In the first study, Elissa simply went to people's houses and talked with the mother, and the little kid was on the floor playing with toys or whatever. Occasionally the mother would say something to the child. We examined those little corpora with speech to the other adult in the room, Elissa Newport, versus speech to the little kid, to see if they were systematically different – which of course they were. But we also looked at how differences in what the mothers said to their children affected the children's language development. Within the normal range of mothers, at least, few of the variations among

the mothers had any effect on what was happening in the children's group – as we measured it. And we measured it in several ways.

In fact, Elissa studied these data to a fare-thee-well for her dissertation (Newport 1975). We were convinced that the maternal style was playing a big causal role in acquisition, so you can't imagine all the analyses that we did. Poor Elissa – she wanted to get her dissertation {finished}, but she kept getting null effects. It took us a long time to realize that that was because the facts were not as we all had supposed. That was the first hint about the relative indifference of the learner to the details of the input (Newport et al. 1977).

Today, of course, we would say that the child is so constructed as to build a grammar of an antecedently well-defined kind, no matter what you do. This was a very primitive first step, which at least shook us a little bit loose. And that's all it could do, because it was just an observational, ultimately correlational study. Food for thought, but that's as far as we could get.

7.3 Acquisition in the Face of Input Deprivation

What we decided to do with a succession of further students was to look at cases of much more radical deprivation of input. Assuming that what you learn is an infinite set of relations between forms and meanings, the input has to be forms and meanings in some way. The first thing you would think of is you hear your mother say "Blah blah blah," and a dog walks by. So you learn that *dog* means "dog." I have only begged about four hundred questions in so saying, but that's the start of the idea.

7.3.1 Deaf Children

Now, what if you have a kid who is deprived of information about the forms or the meanings? How could you study that? Well, somebody came from the Pennsylvania School for the Deaf to talk to our seminar about deaf children, and we found out from them – and there's a descriptive literature on this topic – that deaf children who are in homes where there is no sign language begin to make iconic gestures spontaneously. People have studied such gestures, and maybe sign language comes from such original gestures. So this might be a route to look at the origins of language in the child and, maybe, somewhat more extravagantly than I {actually} believe, the origins of language.

Susan Goldin-Meadow, Heidi Feldman, and I had already been convinced by emerging work from [Ursula] Bellugi and others (Klima and Bellugi 1979) that indeed sign language really was a language. We decided to look at deaf children at the stage before they get sent to "deaf school." In those cases we were looking at, the parish priest would counsel the parents, "Don't gesture to your little deaf child, because if you do they will become too lazy to learn a real language when we send them to deaf school at the age of about five." So here are these little children in your house exposed to no language whatsoever.

I should point out that, as with Newport, Goldin-Meadow's first looks here at isolate language, and deaf language, transmuted into her life's work on gesture and sign; and that she too became one of this growing group of people who formed our circle of thought and continue collaborating to this day.

The first idea was to go to these children's houses and see what we could see, and it's hard to believe until you see it. In one of our videotapes, Heidi shows a picture of a snow shovel. And this three-year-old points to the snow shovel and produces a gestural monologue of how, when it snows, he puts on his boots, he goes outside, he shovels the snow, and so on. And he expresses himself marvelously well.

So there's step one. And you might say, if you were a minimalist, that there you go, we're done, that's language. Or you might say, well, maybe we can do more with these data.

I already believed that every verb comes with its own mini-grammar, as per The Great Verb Game. And if these children had the same logical ideas that you and I have, then they would believe that *give* involves three arguments, and you map it onto language with an NP for each argument, roughly speaking. So *give* and *sleep* and *eat* ought to behave in different ways structurally. Now we asked (Feldman et al. 1978), for the seven deaf kids that we looked at, do they make this distinction?

Now you have to become a psychologist, because life is very tricky – little kids at this age produce first only one gesture at a time, then two, then three, then many. But the two-word period of language production is when we had most of our data – *Mommy sock* and all that. So how are you going to find out whether *give* and *eat* and *sleep* have different structures?

Well, let's pretend for the moment – this turns out to be a good pretense – that as far as the output system is concerned, there's this period in which you only have two spaces. You can only say two things. You've got to say the verb. Now, it should be that the required argument always appears as an overt gesture. So where you have {an intransitive verb like} *sleep*, everything is fine, but where you have *eat*, each of its arguments will be produced only half of the time, because one space is taken by the verb. You can just do the arithmetic. And for *give*, {as in *She gave him the cake*}, the proportion should be even lower,

But another thing about language use is that, when an argument goes unmentioned, it's usually the subject. In fact, this differential omission of the subject NP could easily be seen in the patterns of the deaf children's signing. They "dropped" the subject proportionally more often as the number of required NPs for some predicate increased. Perhaps this is what was later known as "pro drop" in linguistic circles.[2]

That's what we found – for every kid and every predicate. These children exhibit understanding of argument structure, but filtered through this output constraint. Subjects are treated differently from other arguments and words appear in different structures depending on what they mean. And where did that come from? Not from their mothers.

The evidence against my empiricist leanings was starting to pile up here. I was becoming more open-minded. But I always had to fight against my innate empiricism [laughter].

7.3.2 Blind Children

A couple of years later, along came another brilliant person, whose name was Barbara Landau. She wanted to work on language of the blind. I said to her, "Why would you do that?" And she said, "Well, like you looked at the deaf." And I said, "Yeah, and later we'll do people with a broken arm?"

And she said, "But there's a reason." Because to some extent they're cut off from the meanings, or at least from the referents. When you say "It's a cloudy day," they're cut off from the clouds. There's some difference or diminution in your ability to relate the words that you hear to what's going on in the world. And after all, you "must" have learned your language that way – of course, a topic that both Locke (1690) and Hume (1738–1740) had discussed centuries earlier.

So this poor blind child who can't see should be slower in learning and should learn weird things. He should fail to learn some things; we didn't quite know what.

You can predict my first empiricist thought: The child could only learn words for things you could reach out and touch, because touching things has to be their way of getting information. This is what every empiricist should say: You're only going to learn words whose meaning you can get evidence for from the outside world, even though you're blind. So imagine our shock. This changed my whole life. Here's where I fell over the edge. The first verb in this kid's vocabulary was: *see*! With *look* not far behind.

And just as advisors to the parents of deaf children had said, "Don't gesture to your child," clinicians tell the parents of blind children, "Don't use words like *look* and *see* to your blind child, because that will lead to empty verbalism." It's a technical word, *verbalism*. Why? Because, they say, *look* and *see* could have no meaning to the blind.

In fact, when Landau asked the blind child to "look up!", the child raised her hands as if to explore, keeping her eyes and head immobile. This is in contrast even to blindfolded, sighted three-year-olds, who in response to the same command will raise their covered eyes skyward. This was a first demonstration (followed by corroborating evidence) that knowledge of sight-related concepts is abstract rather than limited to the visual apparatus in particular, and that a blind three-year-old has means to discover this (Landau and Gleitman 1985). How could they have learned this? Our answer, as it evolved, turned out to be: They play The Great Verb Game, reverse-engineering the meaning from the form. That is, it is the appearance of *look* and *see* with sentence complements (*Let's see if there's cheese in the refrigerator*) that informs the learner that *look* and *see* are terms of perception, not mere contact (one can't say or understand *Let's touch if there's cheese in the refrigerator*).

7.3.3 Nicaraguan Sign Language: No Linguistic Input

Linguists, including particularly Anne Senghas (Senghas et al., 1997), had the opportunity (and, I might add, the wit) to look at a remarkable case of a language rising in a hithertofore-isolated deaf community. These were children in the area of Managua, Nicaragua, brought together in a kind of informal deaf club. The result, as Senghas and her colleagues showed, was a constantly self-enriching gestural system that in semantics and syntax embodied the elements of known natural languages, spoken and gesture.

I had the opportunity to work with Senghas, Goldin-Meadow, and [Molly] Flaherty on studies of my favorite abstraction, symmetry (and its entailed cousin, reciprocity), in this population (L.R. Gleitman, S. Goldin-Meadow, A. Senghas and M. Flaherty, {2019}). This work fed several of my obsessions at the same time. It was a new testbed in which an experience-deprived user population showed how abstractions like symmetry and reciprocity arise under untutored conditions, and how this delicate formal distinction is reflected in the emerging syntax of their language.

Even the very first user-inventors of this sign language formally distinguished between symmetrical predication (*Juan and Carlos high-five*) and reciprocal predications

(*Juan and Carlos punch each other*). Just like English speakers, these untutored children treat the symmetric predicate *high-five* as an intransitive verb, with the conjoined *Juan and Carlos* viewed as a single collective subject argument whose parts are symmetrically involved in the action. In the Nicaraguan Sign Language equivalent for reciprocal *Juan and Carlos punch each other*, one finds JUAN CARLOS PUNCH–GET PUNCHED CARLOS JUAN PUNCH–GET PUNCHED, where the serial verb construction PUNCH–GET PUNCHED encodes a transitive action with two animate participants, agent and patient. The reciprocal construction puts two such clauses together, with participant order reversed, describing the two reciprocal events.

Remember, there was no input that accounts for this knowledge. I take this and the many related findings from Nicaraguan Sign Language to be the most compelling evidence for the robustness of the human language learning function to differences in external experience.

7.4 Syntactic Bootstrapping: Verbs of a Feather Flock Together

Coming from the work on the blind child, I had another interesting experience. I said to Henry Gleitman, one of the most thoughtful people I know, "Look! So much for your empiricist ideas! A blind child understands the meaning of the words *look* and *see*." He says, "Well, that's really fantastic. How did she learn them?"

I said, "Heh. You and your—. I don't have to answer that question, really, it's—." And then I thought, Uh-oh. I decided to make a pilgrimage to Cambridge to visit Noam Chomsky, a person of an entirely different persuasion, and a friend of mine, of course, by that time. And maybe I'll get some help in thinking about this. I told Chomsky, "The first verbs in a blind child's vocabulary include *look* and *see*!" He says, "Wow! That's fantastic! How did she learn them?"

Oh my God. When Henry Gleitman and Noam Chomsky are asking me the same question I'm really, really in trouble. Noam says to me, "Well, it couldn't have been by magic!"

There are a number of questions that really have to be asked at this point. Where did the kid come up with the concept of looking? How do you know that the word *look* is the word for looking – which is approximately "apprehend" despite the fact that its usage, for the blind, requires touching? What led the blind three-year-old to distinguish looking and touching?

That's when my memories as a linguist, and conversations with Barbara Landau, brought back "chains of transformations" and The Great Verb Game. If you can't learn the meaning of *see* by seeing, perhaps its sense reveals itself in the syntactic structures it licenses. This hypothesis turns on the following idea. If sentence structures are projected from their semantics, then to some extent the semantics itself may be recoverable from the observed surface syntactic forms. Just Harris's position! In fact, such a theory may not be merely a fallback used by the sensorily deprived, but a general clue to the acquisition of word meanings, for almost every word is abstract and mind-driven and requires more than observation of the world to understand.

Indeed, we discovered that the verbs of cognition and perception as used by the mother to her blind child crucially included sentence complements such as *Let's see if there's cheese in the refrigerator*. In contrast, *Let's touch if there's cheese in the refrigerator* never occurred. And it's by using this information that the congenitally blind child learns to "see."

That's basically the answer. You could now reverse-engineer it. That is, if you knew about how languages must map from semantics to syntax, and somebody gave you the syntax, you ought to be able to reconstruct something about the semantics, down to some level.

And that's what we called "syntactic bootstrapping," a term which I invented to mock my good friend Steve Pinker's "semantic bootstrapping" (Pinker 1984). Pinker, who was right in many ways, was saying that you can acquire the syntactic structures by understanding the semantics. But everything I was doing was saying you can't, because that semantics business that he thinks you should have first isn't so easy. While Pinker's premise was false in part, there's something deep in his work about how the syntax–semantics correspondence can help you learn semantics. We get the main clues from what we learned from the deaf and the blind – that you can exploit that correspondence from the other end. At the point where verb learning is going on, enough syntax is accessible for the child to perceive. And from that, if you're a creature endowed in a certain way by nature, you can make a very good guess about the semantics of the verb in a sentence.

Here is an important detail. A verb will occur in several syntactic environments, some with varying numbers of arguments. So one can say, *I gave a book to John*, or *I gave at the office,* or *I gave cash*. But the maximal number of arguments semantically partitions the verb set in useful ways.

Of course this is complicated. But you know, infants aren't just infants; they're smart [laughter]. Right? So the relationship between number of arguments and number of NPs – there's something natural about it. And the same is true for the relation between sentence complementation and words like *look* and *see*, since we can perceive both objects and states of affairs. Therefore, just as in the original Great Verb Game, listener-learners require several framing structures to retrieve the semantics of individual words.

[Mark: Is it fair to say that your syntactic bootstrapping theory is sort of a redemption of Zellig Harris's syntactic discovery procedures on the basis of transformational relations among sentence frames?] Right! Exactly. Because as a child, you don't get to hear underlying structures. You hear some form of a surface sentence. And you have to do something with it. So, yes, I think it's basically Zellig Harris rediscovered, redeemed, and put to purposes which he would hate [laughter].

But how else would you really understand Harris's theory? Here's how Harris expressed it: "You know, you really put together a grammar by intuition. But to have a theory you have to show that it could be mechanically invented." You have to show that you could have done it algorithmically. A machine could have invented it. That was his story. And that machine which could have invented it is the theory of language.

Well, I believe that too, but I believe that's the language acquisition device, fondly referred to as Universal Grammar.

{The following Sections from original article have been omitted here:

sec 5. TAKING THE THEORY INTO THE LABORATORY
sec 6. THE HUMAN SIMULATION PARADIGM
sec 7. EASY WORDS: FIRST STEPS IN ACQUIRING THE LEXICON
sec 8. CONCEPTS
sec 9. WHORF: DO CONCEPTS COME FROM LANGUAGE ITSELF?}

7.10 Thoughts about the Future

After this long odyssey about our studies in language acquisition, let me return to Chomsky's early proposal concerning "the poverty of the stimulus" (the series of insights about the "stimulus-free" nature of language learning and use). Most generally, Chomsky has invited us to consider the human Mind in light of the fact that every normal child acquires any known natural language to an expert level in a relatively brief period of time in infancy and early childhood, based on the hearing (or gesturing, in the case of sign language) an adventitious set of sentences in context.

In contrast, behaviorist psychology saw language learning as an instance of more general principles of operant conditioning, a relatively straightforward distillation and organization of experience. But the models presented, as Chomsky argued, never offered a plausible account of the dimensions of structured generalization.

Classical AI raised an analogous argument by analyzing intelligence as applied logic. But logic and formal language theory left language open to massive and pervasive ambiguity, even if the "grammar" could be learned perfectly. So the next generation re-interpreted intelligence as applied probability. This worked much better, except when it didn't.

Useful examples come from the so-called Winograd Schema Challenge (Morgenstern et al., 2016). Consider the following sentences:

The town councillors refused to give the angry demonstrators a permit because they feared violence.

Who feared violence?

Answer 1: the town councillors
Answer 2: the angry demonstrators

Here the special word is "feared" and its alternate is "advocated" as in the following:

The town councillors refused to give the angry demonstrators a permit because they advocated violence.

Who advocated violence?

Any average 10-year-old can resolve these ambiguities flawlessly. But after years and years of machine modeling, these devices still go 50–50 on the chosen resolutions. Even the newer "deep learning" networks, which require exponentially more training data than humans do, learn things that humans would never consider and lack the ability to integrate common-sense reasoning.

Perhaps the core problem for the machine learner is that he never gets the joke. He mulishly acquires what is most probable and is stymied by the improbabilities of everyday life. Instructive for this problem are several newspaper headlines collected by Steven Pinker and republished in his {(1994/2007)} book *The Language Instinct*. One example is "Queen Mary has bottom scraped," which makes every listener chuckle, but the machines have no useful chuckle routines. Another example from Pinker was the headline, "Man gets six months in violin case." True, humans and not machines know how this choice should "usually" be made and therefore giggle, and so opt for

the interpretation of "case" as litigation rather than container. But now consider the recent escape of the billionaire Carlos Ghosn from the Japanese legal system, which was accomplished indeed by his secreting himself inside a violin case (a double bass case, but who's counting). The point is that we humans can understand the probabilities in the world so as to interpret ambiguity and take this into account, but when the improbable becomes the actual, we continue to understand.

These are the kinds of formal and substantive properties of language and thought that Chomsky has invited us to consider from the earliest to most recent of his writings. So extravagant did these claims seem at the time when I first read them that they set the stage for my life's work in fleshing out details with experiments relevant to this topic, namely, that is, how radically could experience differ and still support language learning. This is why we considered the deprivation of experience in the blind and isolated deaf.

Chomsky continues to frame and expatiate upon the central questions of language learning and knowledge, and I stand very much in his debt.

7.11 Conclusion

In many ways, I think of my lines of work as (partly inadvertent, partly adventitious) elaborations of several of the approaches to language and mind that Chomsky and [Jerry] Fodor brought into the study of language, thus creating a more general revolution in how cognitive science thinks about the nature of mind. The most general conclusion pertains to how much and how widely knowledge is a function of the structure of mind, and how restricted the influence of experience is. This is why the many studies of acquisition in infants with deprivation of input showed so little effect on the final product.

At the same time, there is much to be said in support of Zellig Harris's perspective, which looks so different on the surface. After all, Harris held, and so did Plato, that the knowledge we had at birth is forgotten. I interpret this to mean that although we are surely endowed with a language capacity, we forget, or never knew, how it is instantiated in English in particular. For the latter, we have to observe and integrate the evidence that is provided in the surface forms of the exposure language.

If I had to summarize the odyssey that this succession of studies chronicles, the two-line conclusion might be: Language acquisition is obviously impossible, but somehow they do it. Empiricism is innate, but somehow we get over it.

At peril of going on forever here, I do want to say a few more words about how this enterprise unfolded, for it was certainly a product of "groupthink." Henry Gleitman (ultimately the teacher of all of us collaborators) started a research seminar in which we all continued to talk for almost half a century. After a while, it came to be called "the cheese seminar," because of the refreshments provided halfway through these long evenings of talk, and then, with the addition of insights and methods from Trueswell's students joining this larger group, "the cheese and trackers seminar" – not only cheese and not only eye-tracking. It was decades of cross talk and collaboration, continuing to this very day, for a great circle of young scientists, some of whom I've mentioned in sketching the styles of investigation and explanation that emerged from this group. And I'm glad to say that I'm more than proud, that this seminar continues: I am particularly proud to say that in the present incarnation of this kind of research seminar, now led by Trueswell,

my very first postdoc and early collaborator, Sharon Armstrong (professor of psychology at LaSalle University), continues to attend and to contribute to the next generation of this half-century-long conversation.

Language learning isn't really instantaneous; it happens in real time.

Endnotes

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2 "Pro-drop" refers to the property of allowing omission of the subject noun-phrase while maintaining grammaticality. Thus in Spanish, one can say "Hablo Espanol," in effect "speak Spanish" without the subject ("I", or "Yo" in Spanish) being uttered. Thus the (pro)noun has been dropped in the spoken sentence. English, at, at the other extreme in this regard, require's an overt subject even where the semantics does not require it, e.g. we say "It is raining" even though we have no "it" in mind as the agent or actor of a raining event.

References

Brown R, Cazden C, Bellugi U. 1968. The child's grammar from I to III. In *Minneapolis Symposium on Child Psychology*, vol. 2, ed. JP Hill, pp. 28–73. Minneapolis: Univ. Minn. Press

Chomsky N. 1957. *Syntactic Structures*. The Hague: Mouton.

Chomsky N. 1959. A review of B.F. Skinner's Verbal Behavior. *Language* 35:26–58.

Chomsky N. 1965. *Aspects of the Theory of Syntax*. Cambridge, MA: MIT Press.

Chomsky N. 1959. *A review of B.F. Skinner's Verbal Behavior. Language 35:26–58 Chomsky N*. 1965. Aspects of the Theory of Syntax. Cambridge, MA: MIT Press.

Fisher C, Gleitman H, Gleitman LR. 1991. On the semantic content of subcategorization frames. *Cognitive. Psychology.* 23:331–92.

Gleitman H, Gleitman LR. 1979. Language use and language judgment. In *Individual Differences in Language Ability and Language Behavior*, ed. C Fillmore, D Kemler, W Wang, pp. 103–26. New York: Academic Press.

{Gleitman, LR, Goldin-Meadow, S, Senghas, A, and Flaherty, M. (2019 Proceedings of the National Academy of Sciences 116(24):11705-11711; https://doi.org/10.1073/pnas.1819872116

Gleitman LR, Rozin P. 1977. The structure and acquisition of reading: relations between orthographies and the structure of language. In *Toward a Psychology of Reading*, ed. A Reber, D Scarborough, pp. 55–141. Hillsdale, NJ: Erlbaum.

Harris ZS. 1951. *Methods in Structural Linguistics*. Chicago: Univ. Chicago Press.

Harris ZS. 1952. Discourse analysis. *Language* 28:1–30.

Hirsh-Pasek K, Gleitman LR, Gleitman H. 1978. What did the brain say to the mind? A study of the detection and report of ambiguity by young children. In *The Child's Conception of Language*, ed. A Sinclair, RJ Jarvella, WJM Levelt, pp. 97–132. Berlin: Springer.

Hume D. 1738–1740. *A Treatise of Human Nature*. Oxford, UK: Oxford Univ. Press.

Klima ES, Bellugi U. 1979. *The Signs of Language*. Cambridge, MA: Harvard Univ. Press.

Landau B, Gleitman LR. 1985. *Language and Experience: Evidence from the Blind Child*. Cambridge, MA:Harvard Univ. Press.

Locke J. 1690. *An Essay Concerning Humane Understanding*. London: Thomas Bassett Medina TN, Snedeker J, Trueswell JC, Gleitman LR. 2011. How words can and cannot be learned by observation. *PNAS* 108:9014–19.

{Morgenstern, L., Davis, E. and Ortiz, C. (2016), Planning, Executing, and Evaluating the Winograd Schema Challenge. *AI Magazine* 37(1):50-54.}.

Newport EL. 1975. *Motherese: the speech of mothers to young children*. PhD thesis, *Univ*. Pa., Philadelphia.

Newport EL, Gleitman H, Gleitman LR. 1977. Mother, I'd rather do it myself: some effects and non-effects of maternal speech style. In *Talking to Children*, ed. CE Snow, CA Ferguson, pp. 109–49. Cambridge, UK: Cambridge Univ. Press.

Pinker S. 1984. *Language Learnability and Language Development. Cognitive Science. Ser. 7*. Cambridge, MA: Harvard Univ. Press.

{Pinker, S. (1994/2007). *The Language Instinct*. New York, NY: Harper Perennial Modern Classics.

Rodd LJ, Braine MDS. 1971. Children's imitations of syntactic constructions as a measure of linguistic competence. *J. Verbal Learn. Verbal Behav.* 10:430–43.

Senghas A, Coppola M, Newport EL, Supalla T. 1997. Argument structure in Nicaraguan Sign Language:the emergence of grammatical devices. In *Proceedings of the 21st Annual Boston University Conference on Language Development*, vol. 2, ed. E Hughes, M Hughes, A Greenhill, pp. 550–61. Somerville, MA: Cascadilla.

Shipley E, Smith C, Gleitman L. 1969. A study in the acquisition of language: free responses to commands. *Language* 45:322–42.

Smith LB, Yu C, Pereira AF. 2011. *Not your mother's view: the dynamics of toddler visual experience*. *Dev. Sci.* 14:9–17.

Part II

Contemporary Issues in Syntax

8

The Architecture of the Computation[1]

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8.1 The Computational Task

Most syntacticians, of whatever theoretical persuasion, will agree that a fundamental property of all human languages is that they pair meanings with sounds or signs (let's call these *forms*) in an unbounded fashion. The syntactic structures of a human language are not appropriately thought of as a finite list. Further, most syntacticians will agree that the form-meaning relationship in human languages is, at heart, hierarchical: forms do not syntactically combine linearly, rather larger form-meaning pairings are built out of smaller ones creating a self-similar hierarchy of phrases. It is the job of syntactic theory to give an account of this pairing and its unbounded nature.

One of Chomsky's earliest contributions is the idea that a theory of the unbounded construction of hierarchical structures should incorporate a computational system that generates the structures (e.g. Chomsky 1959). The history of generative grammar is to a great extent the history of attempts to specify what that computational system is and how it interacts with other systems that account for the details of form (phonology) and meaning (semantics and pragmatics).

Of course, syntactic theory shouldn't just provide an account of the fact that the link between linguistic form and linguistic meaning is unbounded. The theory also has to give an account of why *this* pairing, and not some other.

We can raise this question at two different levels. One level is more general and the questions are of the following sort: Are syntactic structures generally binary (Kayne 1994)? Are the syntactic rules that create structure sensitive to hierarchy rather than linear order (Chomsky 1975)? Are syntactic rules insensitive to the number of times they can apply (Adger 2019)? Are the basic units which syntax is composed of discrete

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rather than fuzzy (Newmeyer 1998)? Can syntactic dependencies that apparently span arbitrarily large structures built out of more local dependencies (Chomsky 1977)? etc.

Generative theories of different stripes have tended to agree that the answers to these questions are positive, and that our theories should capture that. Of course, that said, different theories and approaches have taken different perspectives on many of these these issues. Perhaps syntactic structures can be ternary, with rules that can apply exactly twice to fuzzy categories at certain linearly defined points in a string. Even at this general level, the correct characterization of the phenomena is open to question.

The other level is more particular. Here, the questions revolve around specific linguistic phenomena and generalizations about them. I provide one brief example, which I return to in the final section, but this kind of question is the bread and butter of most work in syntax.

Take a simple sentence with three noun phrases, like (1):

(1) [Lilly]$_Z$ teased [the mouse]$_X$ before she devoured [her food]$_Y$

I have labeled the noun phrases so it's easy to keep track of them.

We can of course ask a simple question about the Subject Z of (1), as follows:

(2) [Which cat]$_Z$ teased [the mouse]$_X$ before she devoured [her food]$_Y$?

We can also ask a question about the Object of *tease*. When we do this in English, there is no noun phrase in the X position, but the question is perfectly well-formed:

(3) What did [the cat]$_Z$ tease X before she devoured [her food]$_Y$?

The meaning can be roughly paraphrased as: What is the thing such that the cat teased that thing before she devoured her food.

In contrast, speakers of English reliably report that asking a parallel question about the Object of *devour*, leaving a gap in the Y position, is degraded:

(4) *What did [the cat]$_Z$ tease [the mouse]$_X$ before she devoured Y?

Here it appears to be impossible to associate the relevant meaning (What is the thing such that the cat teased the mouse before she devoured that thing?) with this form. Indeed, in this case it seems difficult to associate the form with any other meaning either, leading to unacceptability. This then is the question about how forms and meanings pair: Why is the form in (4) not associable with a meaning analogously to (3)?

This discussion illustrates that the theory of syntax needs to explain:

(5) a. the unbounded hierarchical nature of syntactic structure;
b. the general properties of that structure;
c. the specifics of the structure such that it pairs form and meaning in the particular way it does.

There are many possible sources of explanation for these three properties of syntax: the structure-building system itself; the interface between that system and systems of sound (phrasal phonology, word formation, etc.); the interface to the systems of meaning

(variable binding, reference tracking, quantifier scope, etc.); the interface between the computational system and the systems which put it to use in parsing and production; domain general effects of cognition impacting on the system; natural laws acting on the system; the input to the system in terms of the primary linguistic data that the child learner is exposed to, data that is itself affected by historical and sociolinguistic factors.

This paper will focus on the structure building system, what is sometimes called the computational system, as a source of explanation. In some sense it is the fundamental source of explanation in generative grammar, as it accounts for the central question of the unbounded hierarchical nature of the syntax of human language. It also, I will argue, can account for some of the general properties of this hierarchy, and for some aspects of the particulars of form-meaning pairing.

I called the system responsible for creating new pairings between form and meaning the *computational* system. What is the import of the term "computational" here?

8.2 Computation and Syntax

Turing's (1937) analysis of computation takes it to be the composition of a series of elementary functions which are so simple they cannot be broken down into sub-components.

A function is a mathematical object that takes some input and, for that input, produces an output. It maps from a domain to a range, assigning to elements in the domain (possibly multiple elements) a value from the range. Though functions are mathematical objects, they can of course be physically realized by mechanisms in the world (Gallistel and King 2011), or understood as models for them.

A very simple means of defining a function is via a look-up table. For example, we can define addition modulo 4 (that is, where the result is the remainder of the sum divided by 4) by a simple table that looks like this:

(6)

	0	1	2	3
0	0	1	2	3
1	1	2	3	0
2	2	3	0	1
3	3	0	1	2

Here the two numbers to be added are given as an element from the topmost row and an element from the leftmost column; the result of adding modulo 4 can be got by looking at the cell in the table where the relevant row and column intersect.

However, lookup tables are only useful for finite inputs. Addition in general cannot be given via a look-up table of this sort. Even a very simple function which has an infinite input, for example the function that gives you the next item in the sequence of binary numbers, can't be given by a look-up table, for obvious reasons: the table would have to be infinite. This is where the notion of computation comes into its own.

The classic insight here emerges from Turing's work (as well as that of other mathematicians such as Gödel, Church, Péter, and Post – see Kleene 1952), though some of the relevant concepts stretch back to Babbage and Lovelace (Haigh and Priestley 2015). The

ideas that emerged from this research provided a basis for understanding how a finite system consisting of a few fundamental concepts can be used to rigorously define an unbounded outcome. Turing formalized the intuitive notion of an *effective procedure* via an abstract device that could carry out a set of elementary operations on symbols: reading a symbol, writing a symbol and changing the state of the device. A symbol is simply an inscription on some medium with a particular shape – a purely formal entity. Writing a symbol, and then subsequently reading that same symbol requires that the device have a memory. It is the memory that gives Turing's approach its power, as memory allows the composition of functions: the stored output of previously computed functions can feed, as input, into those same, or other, functions.

Other approaches to the same issue were developed at round about the same time. Simplifying a great deal, in Church's work, functions are composed by a general mechanism that substitutes symbols for other symbols; in Post's earlier approach the system moves and deletes symbols; his later approach rewrites symbols in a way familiar to linguists from phrase structure grammars. These approaches are (extensionally equivalent) ways of defining what we now think of as a computational procedure (again, see Kleene 1952 for discussion and references).

The term "procedure" here is somewhat vexed. It has different meanings, depending on the discipline it is used in. Within computational linguistics, it is usually used to refer to the procedure that analyses a string and assigns a syntactic structure to it. That is not the use intended here. Following the use of the term in computability theory (e.g. Minsky 1967), generative grammar takes (part of) an individual's knowledge of language to be possession of such a computational procedure (Chomsky 1995, 14-15). The term "procedure" in this sense refers to a particular means of specifying knowledge that ranges over an unbounded domain (cf. Chomsky 1962, 539).

As mentioned earlier, one of the core insights of early generative grammar was that the infinite range of human languages could be best captured by such concepts. Chomsky's approach to this was influenced most by work stemming from Post's ideas, which differed from Turing's in that it formalized procedures for generating sets, as opposed to computing functions (Soare 2013), making it well suited to answer the questions of how to define an unbounded set of hierarchically structured expressions. Chomsky showed how such an approach could be related to (restricted) Turing style machines to provide an account of the kinds of computational device that could define formal languages, and evaluated the extent to which such mechanisms could be used to give an account of natural languages (Chomsky 1956, Chomsky 1959).

On the surface, one might think that human languages could be viewed as sets of strings of symbols. However, another of Chomsky's early contributions was to highlight the differences between the formal languages Post and others studied and human languages, and to argue that one cannot insightfully treat the latter simply as sets of strings (Chomsky 1963, Chomsky 1980). A fundamental aspect of understanding the syntax of human languages is precisely the pairing of form and meaning, and generating string sets does not give any theoretical purchase on that issue, leaving untouched crucial properties such as ambiguity, sameness of meaning, structure dependency of rules, etc. Generative linguistics therefore takes syntax to be characterized by the *ways* that discrete elements can combine (potentially unboundedly) into hierarchical structures. That means that what is important for the syntax of human language is not the sets of forms defined but the procedure that defines them and relates them to meaning.

It will be useful to tease out six distinct computational issues when we turn to thinking about the properties of the computational system of human language.

(7) a. The nature of the device (the basic operations);
b. The nature of the procedure;
c. The structure of memory in the device;
d. The nature of the symbols;
e. The relationship between abstract specification of a function, and procedures to compute it;
f. The difference between procedures that compute a function, and procedures that use it.

We assume that the I-language procedure needs a device to run on. That device will have a particular architecture. Given the abstract architecture of some version of a Turing machine, there is a *processor* that can read and write symbolic material to and from *memory* following a *procedure*. Evidence as to the particular architecture of that device will come from what the best theory is of linguistic and other phenomena. Generative linguistics assumes that human beings have, or have the wherewithal to develop, such a device as part of their overall cognitive architecture.

A computational procedure is simply a set of statements, defining an unbounded set of pairings. The procedure itself is fundamentally static, (part of) an individual's tacit knowledge of language. It is not a procedure for processing language.

When, in generative syntax, we use temporal metaphors (e.g. "the Verb combines with the Object before the VP combines with the Subject"), this should be understood as a statement about the *logical* structure of the procedure for pairing sound and meaning, not as a claim about how a particular sequence of sounds is processed in real time by a hearer or constructed by a speaker.

Let's examine a simple example to emphasize the point.

Take a Phrase Structure grammar that can generate a sentence like (8).

(8) The cat scratched Anson.

(9) a. S → NP VP
b. NP → Det N
c. NP → PrN
d. VP → V NP
e. V → scratched
f. PrN → Anson
g. Det → the
h. N → cat

These production rules are a generative procedure. Assuming a device with the requisite read/write architecture, and a memory upon which to inscribe and inspect symbols, we can run a computation (more commonly called, in linguistics, a derivation) as follows:

(10) a. S
b. NP VP (by 9a)
c. Det N VP (by 9b)
d. Det N V NP (by 9d)

e. Det N V PrN (by 9c)
f. the N V PrN (by 9g)
g. the cat V PrN (by 9h)
h. the cat V Anson (by 9f)
i. the cat scratched Anson (by 9e)

A derivation/computation is a sequence of structures (organized symbols – in the case of (10), strings) related by operations. The operations in (10) follow the procedure in (9), and involve substitution of one symbol for another via scanning symbols, writing symbols, and moving the system into new states. In the specification of the procedure itself in (9), there is no temporal dimension.

A computation that links (8) with (9) can be run in a number of ways. (10) gives one of these, but there are other computations that derive the same result. We could, for example, have expanded the Object NP symbol before the Subject one, or inserted the lexical items for the Subject before expanding the VP, etc. These different derivations lead to the same outcome as far as deriving the possible pairings between meaning and form is concerned. For such equivalent computations in this Phrase Structure Grammar system, the procedure defines the structure of the sentence irrespective of which computational steps take place "first." In this sense, then, the different routes that the computation can take are logically, though not computationally, equivalent.

We could also run the computation in a different direction entirely. The derivation in (10) starts with the symbol S and proceeds to operate on that symbol. We could equally start with the terminal symbols *scratched*, *the*, *Anson*, *cat*, and run a computation that derives S from these. The specification of the procedure would be the same, but the computation that the device runs would be different. So whether the computation runs top down as in (10), or bottom up, as just suggested, is irrelevant as far as the procedure itself is concerned.

There is no temporal dimension in the procedure then. There is, however, a sense in which there is a dimension of logical precedence. In (10), we expanded NP on line (b) rather than VP, and we expanded VP on line (c). But we cannot expand the NP within VP without first expanding the VP itself. The procedure does not allow this. So here we see the logical precedence inherent in the procedure (the rules or operations) realized as a constraint on the ordering of the lines in the derivation. Metaphorically, the operations have an abstract temporal dimension, and this is reflected in the common way of discussing derivations ("The Verb combines with the Object before the VP combines with the Subject"). However, the procedure itself has no temporal structure (it is a static set of statements).

Since a computation is a composition of a series of functions from symbols to symbols via states of the device, each symbol must be held within some medium (a memory). This is the third computational concept relevant to human language. Each line of the derivation takes up some space, and has access to some of the previous lines (for the case in hand, only access to the immediately preceding line is necessary). To draw on an obvious metaphor, the symbols have an abstract spatial dimension.

So metaphorical time and space are relevant to a computational procedure, inasmuch as the derivations the procedure defines may have dependencies based on rule order and on positions in memory. One might imagine that the procedure itself may be constructed so as to ensure certain properties of this abstract time and space are dealt with in particular ways. For example, if access to only the preceding line of a derivation

is possible, the class of derivations is restricted; or if all nonterminal categories must be expanded before any terminal is, information about terminals would be unavailable for rules expanding categories. For human language, then, it may be that the memory architecture of the device restricts the range of derivational types available to it, and hence the range of functions it can compute.

The question of the architecture of the device, and especially its memory architecture, have barely been touched on in recent research (but see Adger 2017). Memory for computations, whether in man-made computers or in natural computational systems such as DNA, is generally not flat and unidimensional, as is a Turing machine tape. Richer memory structures, for example hierarchical memory structures, make for smaller and more efficient computations (Cook and Reckhow 1973). The mechanism that the device uses to fetch items from memory and to place them there may also be richer in structure (e.g. Berwick and Chomsky 2016, 135–137). Memory architecture in the computational system of human language is very much an open question.

The fourth relevant concept in (7) is the nature of the symbols. Computation is defined over symbols with no regard to meanings they may have. However, the meanings of the symbols, that is, how they will be put to use by other systems, may impact very strongly on the nature of the symbol, and hence the nature of the computation. Thinking of 7 as 1111111 or as 7 or as 111 will impact the nature of the procedure which calculates the successor of 7. A procedure which simply adds a 1 to a sequence of 1s is different from a procedure that looks up the symbol 8, or from a procedure to calculate the successor for a binary number, giving, in this case, 1000.

This is also true for the computational procedure of human language. The specification of that procedure will depend on whether the atoms of the computation are, for example, taken to be lexical items, with rich internal structure (as in the *Aspects* approach, Chomsky 1967), or as functional categories with minimal feature specification (as in many versions of Minimalism today, e.g. Ramchand and Svenonius 2014, Wiltschko 2014, see Svenonius (this volume) for discussion). Further, the richness of the specification of these symbols will be relevant to how the procedure is defined: Are features privative, binary, or do they have richer attribute-value structure (Adger 2010)? Is the information carried by the symbols localized to the symbol itself, or connected to the symbol's structural context (cf. the discussion of inheritance in Chomsky 2008)? If so, how much of the structural context can the device running the procedure access (Citko 2014).

The fifth issue is the difference between an abstract specification of a set (of form-meaning pairs) and a procedure (a means for calculating the pairs). The discussion so far has assumed that the best way to define the unbounded set of pairs is via a computational procedure. There is an alternative, ultimately stemming from McCawley's 1968 suggestion to interpret phrase structure rules not as a procedure but as a set of constraints that directly define a structure. Thinking of this in terms of sets of form-meaning pairs, this would essentially amount to saying that any two symbols can be a pair as long as a series of constraints holds of the pair:

(11) $\lambda <x,y>. P(x, y) \wedge Q(y) \wedge R(x) \wedge \ldots$

Here the various predicates P, Q and R act as constraints on the form or meaning or the form-meaning pair. There may be further relevant variables beyond form and meaning (for example, the grammatical content of the structures themselves). In such

approaches, a grammar is not seen as involving a procedure at all, but is understood rather as a kind of definition as to what a well formed structure can look like (e.g. Rogers 1996, and versions of Lexical Functional Grammar, Optimality Theoretic Syntax, and Head Driven Phrase Structure Grammar).

These different perspectives (constraint-based and derivational) lead naturally to different research agendas about how to explain the three areas identified at the start of this paper: particular phenomena (restrictions on how questions can be constructed etc.), generalizations across phenomena (binarity of branching, structure dependency of rules, numerical insensitivity of rules, etc.), and the overarching unbounded nature of syntax. I briefly return to this issue in the next section.

The sixth and final conceptual issue raised in (7) is the distinction between the grammar and the parser. A grammar is a procedure licensing derivations that pair forms and meanings in an unbounded fashion. A parser is a procedure that finds a structure that can be paired with a meaning when it encounters phenomenal data. The way that spoken human language is processed by human beings places particular restrictions on how to do this (for example, spoken language is encountered as a linear, though possibly multidimensional, sequence). Similar constraints, different in detail, hold for sign language. For neither is it obvious that the auditory or visual signals are presented in a way that is usefully connected to the form part of the form-meaning pair that is derived by the computational procedure (the grammar). This means that there may be all sorts of strategies and heuristics used by listeners in conjunction with their actual grammar to associate an encountered form with a meaning. For example, a chart parser will create an ordered two-dimensional array of the encountered units, and then appeal to the rules of the grammar (the computational procedure) to construct a structure which the grammar associates with the string of units. Human beings are probably not cognitively endowed with chart-parsers, but the basic point holds: the procedure for processing input data is logically distinct from the procedure that pairs forms and meanings. The same issues may hold in the other direction, for whatever device constructs a derivation that is relevant to a thought, though even less is known about this.

There is an alternative conception about the relationship between the parsing procedure and the generative procedure that takes them to be architecturally intimately intertwined, with the architecture of the grammar being dependent on its implementation as part of the processor (Lewis and Phillips 2015). This approach might lead one to expect a grammar sensitive to the time-course of processing, with an architecture that is top-down, left-right. Early work in generative grammar rejected identifying the two procedures (Miller and Chomsky 1963) because of the existence of misalignments between grammatical knowledge and processing. Instead, Miller and Chomsky proposed one system that stores grammatical knowledge as a generative grammar (i.e. a computational procedure), and another that makes use of that knowledge in parsing and other cognitive processing. Both this two-system architecture, and an architecture where the grammar is implementationally dependent on the parser, are logically possible. It is possible to map a computational procedure (a grammar) into a procedure for parsing (e.g. Stabler 1991), and whether the grammar is usually presented through computations that have a bottom-up or top-down orientation is irrelevant for this (see also Stabler 2011 and more recently Hunter, Stanojevic, and Stabler 2019). It is therefore incorrect to claim that grammatical architectures that typically present computations in a bottom-up fashion are incompatible with the time-course of parsing (e.g. Müller 2018, 523).

8.3 A Minimalist Architecture

Early generative grammar adopted a particular perspective on the nature of the device and the computational procedure. The procedure was seen to involve two distinct parts: phrase structure rules that license derivations from which phrase markers can be constructed, and transformational rules that map phrase markers to other phrase markers. The phrase structure rules deal in information about linear order, hierarchical clustering, and grammatical category, all aspects of grammar that were known to be important from research on linguistics over millennia. However, in addition to order, category and hierarchy, it became clear that there were non-local dependency relations that also formed part of the grammar of human languages (Harris 1957). To capture these relations, Chomsky, building on Harris's work, developed transformational rules within an explicitly computational (Post-style) framework. These rules delete, insert, and permute symbols in the phrase marker derived from the initial computation.

The architecture of the computational system of early generative grammar involves a device that carries out elementary operations following a procedure that maps strings of symbols to strings of symbols in two passes (a phrase structure sub-procedure and a transformational sub-procedure). The device's memory is simply the medium on which those symbols are inscribed. As the theory developed over the 1960s, the initial phrase marker came to be associated with certain aspects of semantic interpretation, and the terminal one with (eventually pronounced) surface structure. In this way, the architecture of the computational system is effectively correlated with the two poles of form and meaning. The initial phrase marker, created from the phrase structure rules, is a representation of those aspects of structure relevant to meaning, while the final phrase marker, generated from the initial one by transformational rules, is a representation of those aspects of structure relevant to pronounced form.

As the theory developed further, however, the form-meaning relationship and the two pass computation were decoupled. This was motivated by the discovery of surface structure effects on meaning, by the development of trace theory, and by issues of learnability. The transformational procedure itself was split in three: as well as mapping from the initial phrase marker to a surface structure, new sets of transformational rules were developed that applied to surface structures but had no effect on form, and only an effect on meaning. These rules dealt with issues such as quantifier scope. Similarly, rules were developed that mapped from surface structure to phonological structure, giving the classic Y-model of grammar (Chomsky and Lasnik 1977). Phrase structure rules create D-structure, and transformational rules map from this to S-structure, and from S-structure to both Logical and Phonetic Forms (LF and PF).

The basic architecture of the computational system is, however, the same, with a phrase structure computation distinct from transformational computation. Further development of the theory reduced the amount of information in the rules, with generalizations being stated instead on the structures that the rules derived. Although generative grammar in the Government and Binding era still had a two pass architecture, the explanatory work done by the generative procedure itself was minimized, and empirical patterns were, more and more, handled by constraints (filters) on the phrase structure rules (X-bar theory, binarity) and on the structures created by the computation (ECP, Case Theory, Binding Theory, etc). However, there were also constraints imposed on the transformational component (Subjacency), so that the procedure itself was limited in certain ways. This led to a fairly complex architecture, with multiple sets

of rules and a rich system of constraints on the structures created by those rules. This approach was empirically successful, but the complexity of the computational system is obvious.

Since the early 1990s, in an attempt to reduce this complexity, the various separate rule systems were replaced by a single structure building rule, Merge, eliminating the distinction between the phrase structure procedure and the transformational one. Chomsky (1995) suggested that the computational procedure should be taken to be one which maps a set of lexical items into a hierarchically configured object which has the relevant structure to link form and meaning. The procedure does this in a way very similar to the earliest proposals, via a computation mapping symbols to new symbols. However, the mapping does not, unlike phrase structure rules, rewrite symbols: it merely adds information about how they are grouped.

In the 1995 system, the two operations that build structures are Merge and Move: the former takes two disconnected existing structures and combines them; the latter takes a single structure and alters it. But these are not two distinct rule blocks; the Merge and Move operations interweave, so the architecture is a single pass architecture, rather than involving distinct ordered rule blocks.

Chomsky (2004) makes a further theoretically significant proposal: Move is eliminated as a separate rule. Merge is redefined so that it applies to two existing structures, independent of whether they are syntactically disconnected, or whether one is part of the other. There is then a single mechanism that both builds and alters structure, entailing that there is no way of distinguishing structure-building from structure-transformation via different rule types.

This redefinition of Merge sharpens the issues of what the basic operations are and what they operate on. It also highlights the difference between a definitional view of grammar and a computational one. Take the following inductive definition of Merge (see e.g. Chomsky 1995, Chomsky 2005, p12); the version I give here is from Hornstein 2018):

(12) a. if α is a lexical item, then α is a syntactic object (the lexicon)
b. If α is a syntactic object and β is a syntactic object, then Merge(α, β) is a syntactic object.

(13) For α, β, syntactic objects, Merge(α, β)=$\{\alpha, \beta\}$.

This definition of Merge certainly allows unbounded generation of hierarchically structured objects, but leaves a great deal open. Assume a set of syntactic objects, which we can label A, … , D; then the following are also syntactic objects, given (13):

(14) a. {A, B}
b. {A, {A, B}}

The (a) example is licensed by the second clause in (12) together with (13); the (b) example is licensed by taking {A, B} and the item A within {A, B} to be the relevant syntactic objects. It follows from the second clause in (12) that {A, {A, B}} is also a syntactic object. This latter means of creating new syntactic objects has come to be called Internal Merge, but it is simply an application of the definition.

However, as well as these, the definition also licenses the following:

(15) {{A, B} , {A, D}}

This example is got by assuming that a syntactic computation has already taken place and constructed the object {{A, B} , D }. We then take α and β in our definitions to be the objects A and D, deriving (15). This means of creating a new syntactic object has come to be called Parallel Merge (Citko 2005; see also the Sidewards Movement of Nunes 2001).

The purely definitional approach in (12) also allows a wide range of further types of derivation that may or may not be desirable. For example, assume we have the syntactic objects α=C, β=B, and we have already constructed a syntactic object {A, {A, B}}. Nothing in the definition disallows Merge of C and B, which are both syntactic objects, but given that B is contained within {A, {A, B}}, we have the following result:

(16) { A, {A, {C, B}}}

This licensing of (16), given the previously defined syntactic objects, involves an instance of Merge that inserts an item inside an existing structure (what syntacticians call a "counter-cyclic" operation). Similarly, if we have {A, {C, B}}, then we could take A and B in {A, {C, B}} and derive

(17) {A, {C, {A, B}}}

This would be an example of a movement that takes an element already in the structure and places it deeper inside that structure, another kind of counter-cyclic operation.

Treating Merge definitionally, then, is simple, but it is also potentially expansive, allowing in a wide range of operations on symbols and of derivational types. Some researchers have taken the expansiveness of Merge to be a positive, enriching the descriptive toolbox for syntactic theory (e.g., Richards 2001, Takahashi and Hulsey 2009 on countercyclic operations and Nunes 2001, Citko 2005 on parallel operations).

An alternative perspective is pursued in Adger (2017) and in Chomsky, Gallego, and Ott (2019), where the range of derivational types is restricted by appeal to the architecture of the computational system. To see how this might work, consider, instead of (12), a procedure running on a particular computational architecture. Assume a device, with a set of states, and a memory, as well as the capacity to group symbols. This is the approach sketched by Berwick and Chomsky (2016):

> We can think of the computational process as operating like this. There is a workspace, which has access to the lexicon of atomic elements, and contains any new object that is constructed. To carry a computation forward, an element X is selected from the workspace, and then a second element Y is selected. X and Y can be two distinct elements in the workspace, …, what is called External Merge. Or one can be part of the other, called Internal Merge, …
>
> Berwick and Chomsky 2016

Here there is a device that has as part of its architecture an operation Select. Select identifies an item X from a memory medium (the workspace), it then identifies another item Y either from memory, or within X itself. The second operation that the device can carry out is Merge, which groups the two elements that Select has identified, and writes

the result back to memory (the workspace). As well as the workspace memory, there is a more static memory structure (the lexicon) which can be accessed by the device.

Much is left unspecified in this quote. Does the workspace have structure? How does Select identify the relevant elements? When the result of Merge is written to the workspace, does it replace X and Y, or simply add the result to the workspace? Indeed, we might ask if Select and Merge are correctly characterized, if they are empirically sufficient, and if the assumed memory architecture is correct.

I leave these questions open (though see the cited works above for discussion). I'd like to close this section with the question of where we might find reasonable hypotheses as to answers to them.

Generative grammar has always taken there to be a computational system at the heart of the human linguistic capacity. The general theory of computational systems is built on certain ideas that have a minimizing effect. For example, there are three principles in classical recursive function theory that allow functions to compose (Kleene 1952): substitution; primitive recursion; and minimization (also called bounded search). These are all designed in a way that one might think of as computationally efficient: they reuse the output of earlier computations. Substitution replaces the argument of a function with another function (possibly the original one); primitive recursion defines a new function on the basis of a recursive call to itself, bottoming out in a previously defined function; minimization produces the output of a function with the smallest number of steps.

One of the guiding themes of Minimalist Syntax has been the question of whether one can detect anything like this in the computational system of human language. Is the architecture of the computational system organized in such a fashion that it minimizes computations (Chomsky 1995)?

This question is not a question about the complexity of processing a sentence in real time to give a parse, the nature of memory structure in general cognition, or heuristics for extracting structures from signals. It is rather the question of whether the procedure that generates the set of sound-meaning pairs is structured so that the computations it defines are redundant, allow backtracking, use unneeded computational space resources, etc., or whether they are structured so as to minimize operations, use minimal computational memory resources, define short overall computations etc. The intuition guiding Minimalist Syntax is that pursuing a theory that follows the latter course will give us better explanations for why syntactic phenomena are constrained in the ways they are.

Such an approach can provide a grounding for some of the more general level issues discussed in section 8.1. The core grouping operation Merge generates unbounded hierarchies without imposing linear order, so that rules appealing to linear order are impossible. Binary branching limits redundant computation over such hierarchies by reducing the range of possible computations. If backtracking is impossible, the system cannot count the number of times a rule has applied, and so human languages do not have numerical limits on rule applications.

It can also provide explanations for the more specific questions about limitations on the form-meaning pairings. Take, for example, the commonly agreed notion that apparent long-distance syntactic dependencies are actually local (Chomsky 1977). Why should this be? One possibility is to ground the explanation for certain locality effects in processing (e.g., working memory capacity as in Hofmeister and Sag 2010, though see Sprouse, Wagers, and Phillips 2012). Minimalist Syntax provides an

alternative, which is that minimization of memory in the system that generates the form meaning pairings itself is what is responsible for all dependencies being local. What accounts for apparent long-distance dependencies raised in section 8.1 is that, in certain circumstances, maintenance of what is in the system's memory can be extended (see e.g., Keine 2020 for empirical evidence). In certain circumstances, such memory extension is impossible, limiting possible pairings of form and meaning.

8.4 Summary

Chomsky's early observations that the hierarchical, combinatorial nature of human syntax requires some kind of a computational procedure to be implemented in the human mind is as valid today as it was 60 years ago. The architecture of the mind requires a device, with a procedure that it follows, and a memory for symbol manipulation. The organization of these three computational components (the device, procedure, and memory) changed little over the early history of generative grammar, but a major shift took place in the 1990s when the structure of the device and the procedure was simplified. Simplification of architecture can open up complexity in the range of computations allowed, so a different kind of simplification, minimization of computation, has come to the fore in recent years, and has begun to provide approaches to the question of why grammars of human languages have the structure that they do.

Endnote

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References

Adger, David. 2010. A Minimalist theory of feature structure. In Anna Kibort and Greville Corbett, eds., *Features: Perspectives on a Key Notion in Linguistics*, 185–218, Oxford: Oxford University Press.

Adger, David. 2017. A memory architecture for Merge, http://ling.auf.net/lingbuzz/003440.

Adger, David. 2019. *Language Unlimited: The Science Behind Our Most Creative Power*. Oxford: Oxford University Press.

Berwick, Robert C., and Noam, Chomsky. 2016. *Why Only Us?* Cambridge, MA: MIT Press.

Chomsky, Noam. 1956. Three models for the description of language. *IRE (now IEEE) Transactions on Information Theory* 2: 113–124.

Chomsky, Noam. 1959. On certain formal properties of grammars. *Information and Control* 2: 137–167.

Chomsky, Noam. 1962. Explanatory models in linguistics. In Ernst Nagel, Patrick Suppes, and Alfred Tarski, eds., *Logic, Methodology and philosophy of science: Proceedings of the 1960 International Congress*, 528–550, Stanford, CA: Stanford University Press.

Chomsky, Noam. 1963. Formal properties of grammars. In R. Duncan Luce, Robert R. Bush, and Eugene Galanter, eds., Handbook of Mathematical Psychology, Volume 2. 323–418. New York: Wiley and Sons.

Chomsky, Noam. 1967. The formal nature of language. In Eric Lenneberg, ed., *Biological Foundations of Language*, 397–442, New York: Wiley and Sons.

Chomsky, Noam. 1975. *Reflections on Language*. New York: Pantheon Books.

Chomsky, Noam. 1977. On *wh*-movement. In Peter Culicover, Thomas Wasow, and Adrian Akmajian, eds., *Formal Syntax*, 71–132, New York: Academic Press.

Chomsky, Noam. 1980. On binding. *Linguistic Inquiry* 11: 1–46.

Chomsky, Noam. 1986. *Knowledge of Language*. New York: Praeger Publications.

Chomsky, Noam. 1995. *The Minimalist Program*. Cambridge: MIT Press.

Chomsky, Noam. 2004. Beyond explanatory adequacy. In Adriana Belletti, ed., *Structures and Beyond: The Cartography of Syntactic Structures*, 104–131, Oxford: Oxford University Press.

Chomsky, Noam. 2005. Three factors in language design. *Linguistic Inquiry* 104: 1–61.

Chomsky, Noam. 2008. On phases. In Robert Freidin, Carlos P. Otero, and Maria Luisa Zubizarreta, eds., *Foundational Issues in Linguistic Theory*, 133–166, Cambridge: MIT Press.

Chomsky, Noam, Ángel Gallego, and Dennis Ott. 2019. Generative grammar and the faculty of language: Insights, questions, and challenges. *Catalan Journal of Linguistics*. Special Issue: 229–261.

Chomsky, Noam and Howard, Lasnik. 1977. Filters and control. *Linguistic Inquiry* 8: 425–504.

Citko, Barbara. 2005. On the nature of Merge: External Merge, Internal Merge, and Parallel Merge. *Linguistic Inquiry* 36: 475–496.

Citko, Barbara. 2014. *Phase theory: An introduction*. Cambridge: Cambridge University Press.

Cook, Stephen A., and Robert A. Reckhow 1973. Time bounded random access machines. *Journal of Computer and System Sciences* 7: 354–375.

Gallistel, Charles R., and Adam King. 2011. *Memory and the computational brain: Why cognitive science will transform neuroscience*, Hoboken, NJ: Wiley and Sons.

Haigh, Thomas., and Mark Priestley. 2015. Where code comes from: Architectures of automatic control from Babbage to ALGOL. *Communications of the ACM* 59: 39–44.

Harris, Zellig. 1957. Co-occurrence and transformation in linguistic structure. *Language* 33: 283–340.

Hofmeister, Philip., and Ivan A., Sag 2010. Cognitive constraints and island effects. *Language* 86: 366.

Hornstein, Norbert. 2018. On Merge. In James McGilvray, ed., *The Cambridge Companion to Chomsky*, 69–86, Cambridge: Cambridge University Press.

Hunter, Tim, Miloš Stanojević, and Edward Stabler. 2019. The active-filler strategy in a move-eager left-corner minimalist grammar parser. In Emmanuele Chersoni, Cassandra Jacobs, Alessandro Lenci, Tal Linzen, Laurent Prévot, and Enrico Santus, eds., *Proceedings of the Workshop on Cognitive Modeling and Computational Linguistics*. 1–10. Minneapolis: Association for Computational Linguistics.

Kayne, Richard S. 1994. *The Antisymmetry of Syntax*. Cambridge: MIT Press.

Keine, Stefan. 2020. Locality domains in syntax: Evidence from sentence processing. *Syntax* 23: 105–151.

Kleene, Stephen. 1952. *Introduction to Metamathematics*. Amsterdam: North-Holland Publishing Company.

Lewis, Shevaun, and Colin Phillips. 2015. Aligning grammatical theories and language processing models. *Journal of Psycholinguistic Research* 44: 27–46.

McCawley, James D. 1968. Concerning the base component of a transformational grammar. *Foundations of language*. 4: 243–269.

Miller, George A., and Noam Chomsky. 1963. Finitary models of language users. In R. Duncan Luce, Robert R. Bush, and Eugene Galanter, eds., *Handbook of Mathematical Psychology*, Volume 2. 419–491. New York: Wiley and Sons.

Minsky, Marvin Lee. 1967. *Computation: Finite and Infinite Machines*. Englewood Cliffs, NJ: Prentice Hall.

Müller, Stefan. 2018. *Grammatical theory: From transformational grammar to constraint-based approaches*. Berlin: Language Sciences Press.

Newmeyer, Frederick. 1998. *Language Form and Language Function*. Cambridge: MIT Press.

Nunes, Jairo. 2001. Sideward movement. *Linguistic Inquiry* 32: 303–344.

Ramchand, Gillian, and Svenonius, Peter. 2014. Deriving the functional hierarchy. *Language Sciences* 46: 152–174.

Richards, Norvin. 2001. *Movement in Language: Interactions and Architectures*. Oxford: Oxford University Press.

Rogers, James. 1996. A model-theoretic framework for theories of syntax. *Proceedings of the 34th annual meeting on Association for Computational Linguistics*, 10–16. Stroudberg, PA: Association for Computational Linguistics.

Soare, Robert Irving. 2013. Interactive computing and relativized computability. In B. Jack Copeland, Carl J. Posey, and Oron Shagrir, eds., *Computability: Turing, Gödel, Church, and Beyond*. 203–260. Cambridge, MA: MIT Press.

Sprouse, Jon, Matt Wagers, and Colin Phillips. 2012. A test of the relation between working-memory capacity and syntactic island effects. *Language* 88: 82–123.

Stabler, Edward P. 1991. Avoid the pedestrian's paradox. In Robert C. Berwick, Stephen P. Abney, and Carol Tenny, eds., *Principle-Based Parsing*, 199–237, New York: Springer.

Stabler, Edward P. 2011. Computational perspectives on minimalism. In Cedric Boeckx, ed., *Oxford Handbook of Linguistic Minimalism*, 617–643. Oxford: Oxford University Press

Svenonius, Peter. This volume. Merge and features: the engine of syntax.

Takahashi, Shoichi, and Sarah, Hulsey. 2009. Wholesale late merger: Beyond the A/Ā distinction. *Linguistic Inquiry* 40: 387–426.

Turing, Alan Mathison. 1937. On computable numbers, with an application to the Entscheidungsproblem. *Proceedings of the London Mathematical Society* 2: 230–265.

Wiltschko, Martina. 2014. *The Universal Structure of Categories: Towards a Formal Typology*. Cambridge: Cambridge University Press.

9

Merge and Features: The Engine of Syntax[1]

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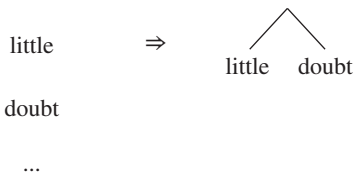
9.1 Introduction

Since the inception of the Minimalist Program (Chomsky, 1993, Chomsky, 1995b), Chomsky has increasingly pushed the boundaries of a minimalist conception of grammar, one that pares the mechanisms specific to language down to the bare bones. Central to this minimalist conception is the notion of Merge. Merge creates complex syntactic objects from simple lexical items: *little* and *doubt* together make *little doubt*.

(1) Lexicon + Merge = Structure



In addition to the structure-building operation of Merge, grammar involves some mechanism for feature interaction. Natural language agreement and concord phenomena and case patterns demonstrate this clearly, for example the sentences in (2a) and (2b), where *she* and *her* are different forms of the same pronoun, conditioned by syntactic structure, and similarly for *they* and *them* and *seem* and *seems*. Note also in (2c–d) that agreement is possible without raising.

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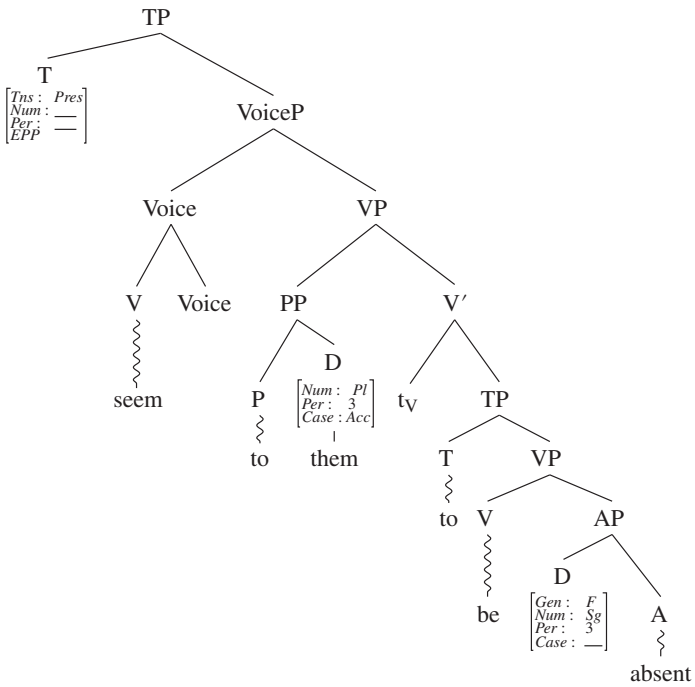
(2) a. She seems to them to be absent.
b. They seem to her to be absent.
c. There seems to them to be somebody absent.
d. There seem to them to be people absent.

In these sentences, the subject gets its thematic interpretation from the lower, infinitive clause, before raising in (2a–b) to become the subject of the finite clause. In the tree in (3), corresponding approximately to the pre-raising stage of (2a), the pronouns are represented by Ds with different features, and the inflection on the finite verb is represented by the feature bundle in the matrix clause (other features and nodes are omitted for purposes of presentation).[2] I depict the main verb *seem* as having undergone "head movement" to a Voice head to precede the prepositional argument *to them*. Two nodes have incomplete feature specifications at this stage of the derivation and so I have not associated them with phonological exponents[3]—the subject pronoun and the finite tense.

(3)



Chomsky (2001, p. 4) notes several things that must be accomplished by a theory of feature interaction. For one thing, the inflectional head T of the matrix clause must copy ϕ-features[4] in order to express agreement. Here, this is accomplished through unspecified values for Num[ber] and Per[son] on T, as indicated with blanks. For another thing, that agreeing relation must skip the argument in the prepositional phrase to find the more distant one in the embedded infinitival complement. Chomsky (2000, p. 123) suggests that the presence of unvalued features makes a node visible (active) for feature interactions—and the D in the PP has its case valued by P, hence has no unvalued features, while the subject of the infinitival does not have its case

valued until it enters into an agreement relationship with the matrix T. Third, finite T requires a subject; in the case of (2a), the D with which it agrees must raise (in (2c–d), the indefinite noun phrases can remain low, and an expletive subject is inserted). This is accomplished through a feature called "EPP" (for historical reasons; see Chomsky, 1982, p. 10).

Chomsky has explored several different varieties of a mechanism AGREE (Chomsky, 2000, p. 101) responsible for these kinds of feature interactions, for example feature matching, feature valuation, and feature movement, as discussed further below.

I discuss Merge in Section 9.2, Agree in Section 9.3, and the possibility of subsuming Agree to Merge in Section 9.4.

9.2 Merge

9.2.1 The Necessity of Merge

In order for a language to be creative, in the sense of being able to encode content that has not previously been encountered, it must have a grammar, a system for combining lexical items (Chomsky, 1964, 1966). Grammars can be stated in terms of constraints on representations (see Sells, Chapter 16 this volume), but sentences are not listed—any speaker of any natural language can spontaneously create utterances which have never before appeared. A derivational model directly manifests the fact of creativity. Architectural assumptions such as the choice between derivation and representation may also have important consequences for the form that explanation takes (see Adger, Chapter 8 this volume, for an example).

In a derivational model, a grammar must include at least a lexicon and a set of operations. Transformational Grammar had phrase structure rules to generate structure, first piecemeal (Chomsky, 1965) and then more generally under the $\overline{\text{X}}$ (X-bar) schema (Chomsky, 1970). In the Minimalist Program, the basic operation combining lexical items is called MERGE (Chomsky, 1995a, p. 396, Chomsky, 1995b, p. 226).

(4) Applied to two objects α and β, Merge forms the new object γ (Chomsky, 1995a, p. 396).

Merge, in addition to applying to lexical items, can also operate on linguistic objects which have been created by previous applications of Merge, a property which introduces the recursive nature of language.

The Minimalist Program leads to the question of whether Merge could be sufficient for narrow syntax (the generation of structures which can be interpreted at the conceptual-intentional interface); that is, could the sole operation of narrow syntax be Merge, with all other aspects of syntactic computation being derived from interface conditions and properties of lexical items?[5]

One can imagine a very simple language consisting entirely of compounds, with free adjunction of lexical words as in *banana-give*. As a thought experiment we can try to imagine what properties such a language would develop in interfacing with systems of

use. In practice, actual implementations of even simple grammatical descriptions of real natural languages always appear to require more than Merge, but in this chapter I will explore some of the ways in which various different mechanisms might be reduced to Merge, in the spirit of the Minimalist Program.

Chomsky describes Merge in terms of set formation, on grounds of simplicity (e.g., Chomsky, 2005, pp. 15–16). On that conception, two elements which are merged form a set, which does not in itself establish any asymmetry between the two (e.g., {*little, doubt*}).

(5) γ is at least the set $\{\alpha,\beta\}$ (Chomsky, 1995a, p. 396)

Sets are mathematically fundamental (Russell and Whitehead, 1913). This does not necessarily mean that set formation is the best model for the ultimately biological processes underlying Merge; computational systems are not set based.[6] However, in the absence of clear evidence to the contrary, the simplest hypothesis appears to be that Merge creates a set.

In $\overline{\text{X}}$ theory, endocentricity (headedness) was built in in the form of "Projection" of a category from the head to the phrase level. This was carried over into early formulations of Merge as follows (where α, β, and γ can be read as referring back to (4–5)).

(6) "… verbal and nominal elements are interpreted differently at LF and behave differently in the phonological component … γ must therefore at least (and, we assume, at most) be of the form $\{\delta, \{\alpha, \beta\}\}$, where δ identifies the relevant properties of γ; call δ the *label* of γ." Chomsky (1995a, p. 396)

(7) "The operation Merge, then, is asymmetric, projecting one of the objects to which it applies, its head becoming the label of the complex formed." Op cit., p. 398

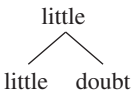
(8) "one or the other of α and β *projects* and is the *head* of γ" (Chomsky, Op cit., p. 397)

Chomsky models this in set-theoretic terms, with one of the two elements forming the label for the whole, as depicted in (9) on the reading where *little* is a quantifier specifying a quantity of doubt (as in, *I have little doubt*).

(9) {little, {little, doubt}}

Represented in tree form, a structure is labeled with the label of its head.

(10)



Chomsky (1995b, p. 248) also proposes another operation, PAIR MERGE, which creates asymmetric adjunction structures. This might be involved in the other reading of *little doubt*, where *little* is an adjective restricting the size of a doubt (as in, *a little doubt grew into a big one*).

See Lasnik and Uriagereka (2012) for discussion of the adjunction structures that motivated Chomsky to propose Pair Merge as an operation distinct from Merge, which is sometimes called SET MERGE to distinguish it from Pair Merge. Hornstein (2009, ch. 4) proposes instead that Merge be decomposed into concatenation and labeling (see below on labels), and that adjunction structures are unlabeled. In that case something like Pair Merge is a subpart of Set Merge.

9.2.2 Movement as Internal Merge

In addition to the Merge of distinct syntactic objects, natural language also exhibits movement, in the sense that there are syntactic objects which must be interpreted in more than one position, e.g., a thematic position like the underlined positions in (11) and a discourse-informational or operator position like the clause-initial positions in (11b–e).[7]

(11) a. They told us to put <u>the pills</u> in cups.
b. Which pill did they tell us to put _ in which cup?
c. The red pill, they told us to put _ in the tall cup (and the blue pill in the short cup).
d. the pills that they told us to put _ in the cups
e. as many pills as they told us to put _ in the cups

In early transformational grammar (e.g., Chomsky, 1965), the base component building phrase structure was thought to be distinct from the transformational component, which included movement (similarly, representational theories of grammar use specialized devices like SLASH or conditions on chains to characterize filler-gap dependencies like those in (11b–d)), but in the Minimalist Program, the existence of movement, and its properties, fall out as a consequence of the way Merge works. Chomsky (2004) proposed to unify movement with Merge by allowing Merge to relate a syntactic object to a subpart properly contained inside that same syntactic object; this is called INTERNAL MERGE (Chomsky, 2004, p. 110; see also Bobaljik, 1995, Starke, 2001).

This substantially increases the importance of Merge as a central component of grammar, and simplifies the inventory of mechanisms, very much in keeping with the aims of the Minimalist Program.

There are at least two ways to think about movement that are consistent with Internal Merge. One is in terms of copies (Chomsky, 1993, Nunes, 1995): the internally merged element exists in two copies which form a "chain." The higher (moved) copy has all the properties of the lower (original) one except its position in the tree, i.e., its set of dependencies.

(12) a. x … x formed by application of internal Merge is a chain; only one occurrence of x is spelled out (the higher, for overt movement)
b. *Who* did they ask *t*?
c. D (spelled out as *who*) … D (its trace) is a chain

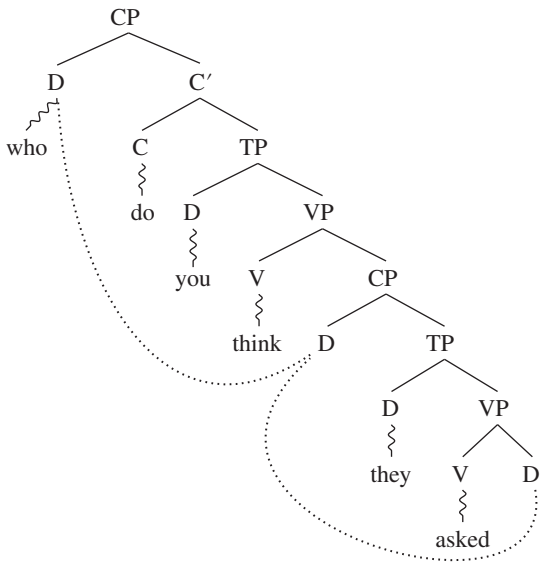
A major accomplishment of generative linguistics is the discovery that movement is punctuated by clause boundaries, or "successive-cyclic" — Chomsky (1973), strongly supported in subsequent work such as McCloskey (2002). McCloskey shows that in Irish, the form of the complementizer directly reflects whether a moved element has passed through the edge of an intermediate clause, providing direct evidence that movement which appears to be "unbounded" in the sense that it may cross multiple clauses actually occurs in shorter steps of approximately clausal size.

In terms of copy theory, a copy is available for a new round of Merge, so that a chain may have several links.

(13) *Who* do you think *t* they asked *t*?

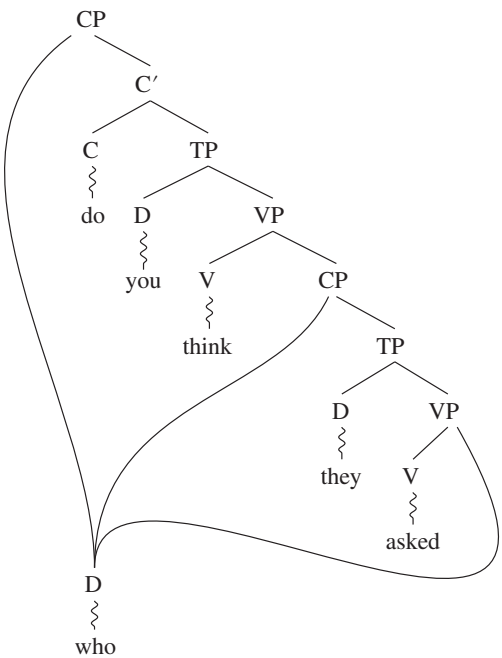
In the tree in (14), the dotted line is the chain. The tree has been simplified to show only heads which are overtly spelled out. I am setting aside the additional landing site at the edge of the verb phrase proposed by Chomsky (1986a) and Chomsky (2001).

(14)



A second way to think about movement is in terms of multidominance (Starke, 2001, Gärtner, 2002). A constituent of a syntactic tree is remerged, or internally merged, with the root of the tree containing it. Thus, a single object enters into two sets of dominance relations, which determines what nodes it c-commands (a node c-commands what it dominates, and its sister, and all nodes dominated by its sister). There is a set of nodes that are c-commanded by an occurrence of an element in a low position, and an expanded set is c-commanded by the occurrence in a higher position. Multidominance is depicted in (15) (as above, simplifying the tree to only show nodes dominating overt material).

(15)



In (15), there is no copy, hence no chain. Instead of copies, three dominance relations for the D *who* are simultaneously represented. Chomsky (2019) observes that such structures violate a "Single Mother Condition." He suggests that copies fall out naturally from minimal assumptions about Internal Merge, and that multidominance requires complications.

9.2.3 The Central Role of Merge

Movement plays an outsized role in generative grammar, including not only the derivation of so-called "unbounded" dependencies (overt A-bar movement, as illustrated for example in (12b) and (13) in Section 9.2.2, unbounded in the sense that they can pass through any number of finite clauses), but also A[rgument]-movement, head movement, covert movements of various types, and possibly others. The extension of Merge to encompass movement establishes Merge as the central operation in grammar, responsible for structure building.

Structure is fundamental to compositionality, which is the backbone of semantic interpretation. Wholly determined by the order of Merge are the differences between (16a) and (16b) and between (17a) and (17b).

(16) a. Jones promoted the conspiracy.
b. The conspiracy promoted Jones.

(17) a. The counsel didn't establish that the defendant did lie.
b. The counsel did establish that the defendant didn't lie.

Structure also determines domains for binding, for example where c-command constrains coreference. In example (18a), *rags* is embedded in the complex subject *linseed*

oil in rags and as a consequence does not c-command *them*, with the result that the two may be coreferent. In (18b), in contrast, coreference with *rags* is only possible with a reflexive, because a nonreflexive pronoun cannot be coreferent with an expression that c-commands it in the same clause (Chomsky, 1980).[8]

(18) a. Linseed oil in $[\text{rags}]_i$ can ignite $\{\text{them}_i/{*}\text{themselves}_i\}$.
b. $[\text{Rags}]_i$ in linseed oil can ignite $\{\text{themselves}_i/{*}\text{them}_i\}$.

Internal Merge plays a critical role in configuring material for semantic interpretation in the theory of covert movement (Huang (1982), May (1985)). Covert movement is exactly like ordinary (overt) movement except that instead of the higher copy being pronounced, the moved element is pronounced in its lower position, as if it had not moved. This means that the position for compositional interpretation is partly dissociated from the position of "surface" pronunciation.

An example is a question with a wh-expression *in situ*, i.e., apparently unmoved, such as the French *où* "where" in (19).

(19) Tu vas où?
you go.PRES.2SG where

"Where are you going?"

If *où* moves covertly, then French-like languages can be unified with English-like languages. Potentially, all wh-questions require a wh-operator to move to a higher layer in the clause, allowing the same rules of semantic interpretation to apply to (19) (and to the inverted *Où vas-tu?*) and to English *Where did you go?* This points toward a universal compositional mapping from syntactic structure to semantic interpretation. Where languages vary is in the mapping between syntactic structure and phonological expression. Chomsky argues that language privileges thought over communication, systematically simplifying the semantic computation at the expense of pronunciation or 'externalization' (Chomsky (2005, p. 4), Chomsky (2007, pp. 12–15), Chomsky (2010, pp. 15–16), Chomsky (2013a, pp. 654–660), Chomsky, 2017).

Merge also plays a key role in word formation, in some implementations of the theory. Yang et al. (2017) mention cases of structural ambiguity at the word level, which can be exemplified here with *[over-fragment]-able* ("susceptible to being too much fragmented") versus *over-[fragment-able]* ("too much susceptible to being fragmented"). Internal Merge plays an important role as well, in the theory of head movement (Baker (1988), inter alios). There, a complex word like the French *va-s* "go.PRES-2SG" in (19) is argued to be formed by syntactic movement (i.e., Internal Merge) of the verb to an inflectional head (e.g., Embick, 2010, Harley, 2014).

Somewhat more radically, it has even been suggested that Merge is responsible for combining phonological segments into syllables and syllables into larger prosodic structures (Yang et al., 2017).

These various extensions of Merge (covert movement, word formation, and phonological structure) are controversial, but they illustrate different aspects of the potential power of Merge as an analytic tool. No rival unification of semantics, morphology, and phonology is visible on the horizon.

As a final example of the ways in which Merge has been extended to cover phenomena beyond the construction and displacement of phrases, I discuss in Section 9.4 below the hypothesis that feature checking itself is a kind of movement (feature movement, Chomsky, 1995b, pp. 262–271; Taraldsen, 1996; Ochi, 1999; Pesetsky, 2000).

9.2.4 Free Merge and Triggered Merge

A question which has been debated recently is the question of to what extent the operation Merge interacts with features of the Narrow Syntax, perhaps being 'triggered' by a formal requirement (Pesetsky and Torrego, 2006), or alternatively "free" and filtered only at the interfaces with other systems (Boeckx, 2010). The matter is complex and unsettled.

Traditionally, lexical heads are thought to have argument structure as a syntactic property, for example verbs can be transitive or intransitive, which can be modeled if the transitive verb has a "selectional" feature which requires it to merge with an object, and the intransitive verb lacks such a feature, and Merge is not licensed in the absence of selectional features (Emonds, 2000).

(20) a. The scientists defeated the virus.
b. * The scientists defeated. (*defeat* is transitive, requires DP)
c. The scientists prevailed.
d. * The scientists prevailed the virus. (*prevail* is intransitive, can't combine with DP)

Functional complementation, for example when the functional T takes a verb phrase complement, or when the functional D takes a noun phrase complement, has been taken to work the same way (Abney, 1987).

(21) a. the dog
b. * the (*the* is "transitive" (requires NP))
c. him
d. * him dog[9] (*him* is "intransitive" (can't combine with NP))

However, the argument structure of verbs is flexible and subject to context and other factors, leading some to argue that argument structure is not regulated by selectional features but by conceptual factors (Borer, 2005), which are not categorical. This would mean that there is something about the concept encoded by *defeat* that makes it ill-suited to intransitive use, while *prevail* is conceptually intransitive, but that Narrow Syntax has nothing to say about that.

This has led to the possibility that Merge in general is not triggered by syntactic features (Boeckx, 2014, Chomsky et al., 2019). It is conceivable that something about the conceptual content of *the* requires it to appear with a noun phrase, and something about the conceptual content of *him* prevents it from doing so; and that this is adjudicated at the interface, beyond the purview of Narrow Syntax. However, this pushes much of what is usually thought of as grammar out of the Narrow Syntax and into the interfaces, highlighting the need for a theory of grammar that includes more than Narrow Syntax.

It is possible to accept Borer's arguments that the contrasts in (20) are not syntactic but to continue to maintain that the contrasts in (21) are.[10]

9.3 Features

9.3.1 Features in Syntax

Chomsky (1965, ch. 2) (*Aspects*) introduced features into generative syntax to capture generalizations invoked by grammatical rules that cross-cut syntactic categories, and the system of features was subsequently developed in important ways (see Muysken and van Riemsdijk, 1986 for the state of the art up to that time).

For example, *where* and *what* both have special properties as wh-expressions, fronted in interrogatives, but *where* corresponds to a prepositional phrase gap (*Where do they live? They live in tents*) while *what* corresponds to a noun phrase gap (*What do they make? They make tents*).

A major issue in *Aspects* which has persisted was to distinguish feature-based constraints holding in the syntax from conditions based on conceptual semantics, which might not be feature based and might not belong in the syntax at all.

9.3.2 Agree

Since the appearance of Chomsky (2000) and Chomsky (2001) there has been an increased interest in developing a minimalist theory of feature interactions (see Adger and Svenonius, 2011 for an overview and references).

As already mentioned in Section 9.1, natural language agreement for ϕ-features provided the model for the operation AGREE (Chomsky, 2000). The basic idea behind Agree is that two nodes in a tree can share values for a feature F if one is a PROBE for F and the other bears F and is sufficiently local to the probe—these facts make it a GOAL.

Thus, the two nodes entering into the Agree relation share something from the outset, namely F, which identifies what kind of information they can share, but are also distinguished in that one of them is a probe, causing it to seek a goal. Adger and Svenonius (2011) call the property that distinguishes a probe from a non-probe a "second-order property" of a feature.

This basic model of feature checking has been developed in many guises. It has been extended to handle selection, movement, licensing, and other operations.

For example, if the verb *live* (in the sense of "reside") selects a PP complement, this could mean that it has a probe for a feature borne by PPs (see Svenonius, 1994 for an implementation). If a negative polarity item like *ever* must be licensed by negation, it could have a probe for a negative feature (Zeijlstra, 2008). A case-marked noun phrase requires a case assigner, so a noun phrase could probe for a class of features carried by case-assigners (see Pesetsky and Torrego, 2001 on modeling case assignment with Agree). Probes can be specified as to whether they require movement of their goal or not (the second order property of "strength," cf. Chomsky, 1995b, p. 232), and whether failing to find a suitable goal leads to ungrammaticality or just the realization of a default value.

Feature checking theory promises to unify agreement, selection, movement, and licensing all in a fairly simple mechanism. This is formally implemented in minimalist grammars like that of Stabler (1997).

In Chomsky (1995b, pp. 280ff) and Chomsky (2000), the second-order property of probes which caused them to trigger operations was the property of UNINTERPRETABILITY. The core idea was that a semantically interpretable feature like number, for example

expressing the plurality of *dogs*, could have an uninterpretable counterpart, for example in a verb form like *are*, which has the same meaning as singular *is* (for example, a plural verb form does not imply anything about the number of events). The interpretation comes from the interpretable instance of the feature on the noun which controls the agreement.

Chomsky (2001, pp. 5ff) proposed that probes were necessarily unvalued, seeking to copy a value from a more fully specified goal, as illustrated in (3). Pesetsky and Torrego (2007) argued that interpretability and valuation were dissociated, and that both were independently needed.

9.3.3 Labels

Chomsky (2008, 2013a, 2015) argues that the imposition of endocentricity on Merge (see (6–8) in Section 9.2) is unneeded. Instead, Merge is taken to be fundamentally symmetric, creating unlabeled, unheaded sets. The source of headedness in syntactic phrases is not Merge, but is to be found at the interface. Specifically, Chomsky, suggests, syntactic objects must be labeled in order to be interpreted at the Conceptual–Intentional interface. Accordingly, an operation Label is introduced that creates a label for a syntactic object before it is interpreted (see also Hornstein, 2009 and Adger, 2013).

The theory of labeling that is advanced in these papers, especially Chomsky (2013b), has important consequences for the theory of features.

In the simplest case, one of the two elements merged is a head, and its label is copied by Label, through "minimal search." Hence, a V merged with an argument is labeled V (VP by convention), a T merged with a predicate is labeled T(P), and so on, for the most part giving the same result as the old theory of Merge-with-projection—or, indeed, $\overline{\text{X}}$ theory, Chomsky (1970).

But Label is not some kind of notational variant of $\overline{\text{X}}$ theory. As Chomsky (2013b, p. 46) notes, the Label theory has the consequence that pronouns like the ones in (3) cannot be simple heads, as they are depicted there, but must be syntactically complex. If they were simple heads, they would provide labels for the phrases that they merge with, so that the PP *to them* and the AP *[her] absent* (or the TP *[she] seems to them to be absent*, after raising) would then have the distribution of noun phrases, contrary to fact.

When two phrases are merged, minimal search does not produce an unambiguous label. A central intuition of checking theory was that the probe and the goal share a feature (as noted in Section 9.3.2). In the same spirit, Chomsky suggests that Label can use a shared feature as the label for the whole. Thus, if a tense head bears ϕ features and it is merged with a subject DP bearing matching ϕ features, the resulting clause can be labeled with those ϕ features (recalling the era of Chomsky (1986b), when the clause was a projection of INFL for 'inflection'). Similarly, if an interrogative CP bears a Q feature and so does a wh-pronoun that merges with it, then the resulting structure can be labeled with the Q feature (see Rizzi (2015) and Chomsky (2015) on deriving "freezing" effects from this).

On this view, no second order probe property need necessarily be involved. If the interface demands labels, and Merge is free, then a structure in which a DP has been merged with a predicate will be unlabeled and hence fail to be interpreted at the interface.

Consider the example of a small clause (like the AP in (3)). Moro (2000) argued that simple subject-predicate combinations were syntactically unstable because they could

not be linearized at the phonological interface, forcing the subject or the predicate to raise. Chomsky (2013b) adopts the notion that small clauses are unstable and require movement, but identifies the instability as being a lack of a label, locating the problem at the Conceptual-Intentional interface.

The DP can move up, but will create the same problem at a higher position unless it finds a node bearing ϕ features with which to merge. The subject may raise to the edge of a phrase with which it shares features, such as INFL or T.

These considerations are sufficient to force the raising of the DP subjects in (2a–b) in Section 9.1 to the finite TP, since the embedded nonfinite T has no ϕ features. They generalize to all clauses with an agent or actor subject, because those have been persuasively argued to be merged with a verb phrase (not simply a verbal head). But there are other sentences in which an adequate low position exists for a DP, and nevertheless something must be inserted in subject position, as in (2c) and (2d)—in English, though not in Italian.

Chomsky (2015) suggests that in null subject languages like Italian, the rich inflection in T provides a label for the object it forms by merging with a verb phrase, but in English, with weaker inflection, T is defective, and cannot label TP unless it is "reinforced" by an overt subject. Thus, the EPP feature in (3) is replaced by a theory of weak label features. In the terms of Adger and Svenonius (2011), weakness would be a second-order property of the features of English T.

Chomsky also discusses another important case in which phrasal Merge does not involve shared features. That is the successive-cyclic movement of an operator to an intermediate landing site (as with the first step of movement in (14)).

An example like (13), namely *Who do you think they asked?* starts out with an embedded clause *C they asked who* (assuming all embedded clauses are introduced by C). The C is not interrogative and the wh-expression cannot be interpreted in this clause. Movement (Internal Merge) is free, so the wh-expression can move to the edge of the clause, but it shares no features with C, so the result cannot be labeled. However, a subsequent step of movement to the matrix C, which is interrogative, results in a labeled structure, and once the offending *wh*-expression has evacuated the embedded clause, the embedded C is free to label the phrase containing it (essentially, traces of movement are ignored by the Label operation).

The fact that movement can never skip an intermediate clause boundary altogether is due to the fact that each clause is separately packaged for interpretation at the interfaces (Chomsky, 2001); this much is constant for the treatments being discussed here.[11] What has shifted is the status of non-feature-driven movement.

The theory of Chomsky (2000, 2001) involved rich featural interactions, as represented in (3). At that stage in the theory, it seemed plausible to imagine that all operations were driven by features, and by second-order properties of features like the probe property. This makes Agree a central component of narrow syntax, alongside Merge (as depicted in the diagram of Minimalist grammar architecture in Alexiadou and Lohndal's (18), Chapter 3 this volume).

However, no independent motivation was found for a feature that could drive the non-final steps of successive-cyclic movement. Subsequent developments, in particular Chomsky (2008, 2013a), change that picture substantially in dialing back the expectation that movement should be driven by second order properties of features—in other words, in the terms of Section 9.2.4 we move from the expectation that Merge be triggered to the expectation that it be free.

Free merge changes the status of intermediate stages of movement. Movement to final landing sites is related to features, but not by second-order properties like strength, or diacritics like EPP. Rather, the interface requires a label, and the algorithm providing labels requires a feature match between the moved element and its host. This has the potential to greatly simplify the theory of features, reducing the explanatory burden on valuation, interpretability and other aspects of the theory of Agree. In fact, Chomsky et al. (2019, p. 252) hint at the possibility of eliminating Agree from the Narrow Syntax, relegating it entirely to the interface.

A challenge, however, is provided by languages like Irish as described by McCloskey (2002). Recall from Section 9.2.2 that Irish complementizers morphologically express a featural distinction between C which is targeted by intermediate steps of successive-cyclic movement, and C which is not. This provided one of the more striking confirmations of the successive-cyclic nature of movement. But it also seems to be at odds with the feature-free account of intermediate steps of movement.

9.4 Feature Movement

The previous sections have been concerned with issues that have been discussed hotly in recent Minimalist approaches to language. In this section, I turn to an issue that does not seem to currently be at the forefront of the research agenda but which I think could have important impact.

Specifically, I briefly discuss the possibility, raised in Chomsky (1995b, pp. 262–271), that the residue of Agree could be unified with Merge. For example, rather than T copying ϕ from D in a structure like that in (3), ϕ could move from D to T (either as a copy, or under multidominance, as discussed in Section 9.2.2).

Movement can be thought of as the creation of a dependency between the head at the root (e.g., interrogative C) and a projection inside the tree (e.g., a D with a [wh] feature). Feature-checking is also the creation of a dependency from one part of the tree to another part, e.g., unvalued ϕ on T and valued ϕ on D (see Frampton and Gutmann (2000) for a formalization of this perspective).

The idea was explored somewhat in the wake of Chomsky (1995b), along with other ways of unifying Merge and Agree (as in Hornstein, 2009), but has not established a broad consensus. Occasionally feature movement has been explored as an alternative to covert movement, but Pesetsky (2000) argues that the two must be distinguished.

The mechanism of Agree was modeled on agreement. One problem with identifying agreement too closely with movement is that ϕ-agreement does not show the properties of the minimal ϕ-bearing elements that actually move, namely pronouns (see Bresnan and Mchombo, 1987 for an early and classic demonstration, and Rezac, 2010 and references there for more recent examples). However, Cardinaletti and Starke (1999) and Déchaine and Wiltschko (2002) have argued that there is a typology of pronouns with different levels of referentiality. Conceivably, ϕ-feature bundles involved in Agree could be lower on a referential hierarchy than other pronominal elements, leading to their failing the tests suggested by Bresnan and Mchombo and others. In that case, agreement might be the movement of a particularly small subpart of D.

Another difference between agreement and movement is that agreement commonly results in the same features being spelled out in two places, while movement ordinarily does not. However, given that Narrow Syntax is the derivation of structures that are

legible to the Conceptual-Intentional interface (cf. Section 9.2.1), the spell-out of movement chains (or of multidominance structures) is a matter of externalization and may not reflect a very deep difference between the two phenomena.

The rise of non-feature-driven movement in the theory of Chomsky (2013b) and associated papers has reduced the importance of Agree, but has not eliminated it entirely. If the residue of Agree could be fully unified with Merge, that would reduce the number of operations in play in Narrow Syntax, fully in keeping with the overall thrust of the Minimalist Program.

9.5 Conclusion

Ever since he started developing linguistic theory in the 1950s, Chomsky has displayed an impressive ability to revise his positions and break with the consensus up to that point, even when the consensus is built on a previous version of his own theory. With each turn, some part of the linguistic community follows Chomsky on the new path, and another part sticks by his earlier position. This was noted by Sells (1985) but has also held true since then.

The issues discussed in this chapter are no exception to that general pattern; Chomsky has held different positions at different times on the nature of Merge, the nature of Agree, and all of the other matters raised here, and for each position there is a camp of adherents who don't think the subsequent moves were on the right track.

Adequate grammatical description of a natural language in the form of a written grammar requires thousands of pages of detail. But much of this concerns the properties of lexical and functional items, for example the properties of *which* or *since* or *as*. One consistent point throughout Chomsky's Minimalist Program is the pursuit of the hypothesis that the grammatical component is very simple, and it is only through the interaction of this simple grammar with the individual properties of lexical items that a complex grammar emerges.

In this chapter I have explored some ways in which the ideal of a maximally simple grammatical component has been approached. The most indispensible grammatical operation is Merge (Section 9.2). The features of lexical items that differentiate them from each other syntactically interact with grammatical operations, which may include Agree (Section 9.3). However, Agree might be partially or even wholly subsumed under a suitably generalized notion of Merge (Section 9.4).

Endnotes

1 Thanks to Nicholas Allott, Terje Lohndal, Kristine Bentzen, and Noam Chomsky for comments on earlier drafts.

2 Standard abbreviations for syntactic categories used here include D[eterminer] (including pronouns), V[erb], T[ense] (for clauses), A[djective], and in later trees also C[omplementizer] (for clauses extended by a complementizer, a subordinator or a marker of illocutionary force).

3 An exponent is the phonological information associated with a syntactic head, here connected to the syntax with squiggly lines.

4 Chomsky (1981, p. 330) identified person, number and gender as the formal features which constitute pronouns and traces of movement, and dubbed them "ϕ-features."

5 This has been stated in various forms as a working hypothesis, for example in Hauser et al. (2002, p. 1573): "FLN [the faculty of language in the narrow sense, "the abstract linguistic computational system alone, independent of the other systems with which it interacts and interfaces"] comprises only the core computational mechanisms of recursion as they appear in narrow syntax and the mappings to the interfaces." Chomsky (2008, p. 139) refers to Merge, again in the context of a hypothesis, as "the sole computational operation of narrow syntax." Chomsky (2010, p. 52) characterizes the *Strong Minimalist Thesis* as "Interfaces + Merge = Language," a thesis to be tested and evaluated. In the same vein, Chomsky et al. (2019, p. 237) write "given that [Merge] is what is minimally necessary to create hierarchical structure, we assume that this is the *only* operation defined by UG," though they mitigate this in a parenthetical alluding to Pair Merge, on which see below. See Fitch et al. (2005) for pushback against the characterization of their (Hauser, Chomsky, and Fitch's 2002) position as claiming that Merge is all there is to FLB, the faculty of language in a broad sense. See also Adger this volume on the difference between the syntactic computation and, for example, processing.

6 For a freewheeling discussion of Merge and set theory, the interested reader may wish to consult a post by Norbert Hornstein on the *Faculty of Language* blog on February 12, 2017, and the ensuing discussion in the comments section of that blog. For example comments by Thomas Graf on February 26th regarding the inappropriateness of sets for computational applications are relevant here.

7 The fundamental uniformity of these different constructions, developed especially in Chomsky (1977), is a major discovery of generative linguistics.

8 I depict *rags* in (18b) as the locus of reference to highlight the asymmetry with (18a), but the same facts hold if it is the complex expression *rags in linseed oil*, with *rags* as its head, which bears reference.

i. [Rags in linseed oil]$_i$ can ignite {themselves$_i$/*them$_i$}.

9 This is bad as a determiner phrase, not to be confused with a compound like *he-dog*, which would have stress on *he* and could refer to a male dog or a masculine dog. Compare the phrasal *you dogs*, where it could be argued that the pronoun *you*, unlike *he* and *him*, is optionally transitive.

10 In that case (20b) and (20d) should actually be marked with crosshatches to indicate semantic anomaly, rather than asterisks to indicate ungrammaticality.

11 The gist of Chomsky's (2001) PHASE theory is that when C is merged, its complement TP is interpreted. Assuming that a wh-expression must be associated with an appropriate C at the time of interpretation, then a TP that contains an unassociated wh-expression will not be interpretable, unless the wh-expression moves out of it, to the nearest available C—the one that triggered the spell-out of TP (and possibly not the final C with which the wh-expression will be associated). At that stage of the derivation, there are no higher positions.

References

Abney, Steven. 1987. *The English Noun Phrase in Its Sentential Aspect*. PhD thesis, MIT, Cambridge: MIT Press.

Adger, David. 2013. *A Syntax of Substance*. Linguistic Inquiry Monograph 64. MIT Press, Cambridge: MIT Press.

Adger, David. This volume. The architecture of the computation.

Adger, David and Peter Svenonius. 2011. Features in minimalist syntax. In Cedric Boeckx, editor, *The Oxford Handbook of Linguistic Minimalism*, pages 27–51. Oxford University Press, Oxford.

Alexiadou, Artemis, and Terje Lohndal. This volume. The current state of generativism: From Government and Binding to Minimalism.

Baker, Mark C. 1988. *Incorporation: A Theory of Grammatical Function Changing*. University of Chicago Press, Chicago.

Bobaljik, Jonathan David. 1995. In terms of Merge: Copy and head movement. In *MIT Working Papers in Linguistics 27: Papers on Minimalist Syntax*, pp. 41–64, MITWPL. Cambridge, Ma. MITWPL.

Boeckx, Cedric. 2010. A tale of two minimalisms: Reflections on the plausibility of crash-proof syntax and its free merge alternative. In *Exploring Crash-Proof Grammars*, edited by Michael T Putnam, pp. 105–123. Language Faculty and Beyond 3. John Benjamins, Amsterdam.

Boeckx, Cedric. 2014. *Elementary Syntactic Structures*. Cambridge Studies in Linguistics 144. Cambridge University Press, Cambridge.

Borer, Hagit. 2005. *The Normal Course of Events (Structuring Sense, vol. II)*. Oxford University Press, Oxford.

Bresnan, Joan, and Sam A. Mchombo. 1987. Topic, pronoun, and agreement in Chichewa. *Language*, 63(4):741–782.

Cardinaletti, Anna, and Michal Starke. 1999. The typology of structural deficiency: A case study of three classes of pronouns. In *Clitics in the Languages of Europe*, edited by Henk van Riemsdijk, pp. 145–233. Empirical Approaches to Language Typology. Mouton, Berlin.

Chomsky, Noam. 1964. *Current Issues in Linguistic Theory*. Janua Linguarum Series Minor 38. Mouton, The Hague.

Chomsky, Noam. 1965. *Aspects of the Theory of Syntax*. MIT Press, Cambridge, Ma.

Chomsky, Noam. 1966. *Cartesian Linguistics: A Chapter in the History of Rationalist Thought*. Harper & Row, New York.

Chomsky, Noam. 1970. Remarks on nominalization. In *Readings in English Transformational Grammar*, edited by Roderick A. Jacobs and Peter S. Rosenbaum, pp. 184–221. Georgetown University Press, Washington, D.C.

Chomsky, Noam. 1973. Conditions on transformations. In *A Festschrift for Morris Halle*, edited by Stephen R. Anderson and Paul Kiparsky, pp. 232–286. Holt, New York.

Chomsky, Noam. 1977. On wh-movement. In *Formal Syntax*, edited by Peter Culicover, Thomas Wasow, and Adrian Akmajian, pp. 71–132. Academic Press, New York.

Chomsky, Noam. 1980. On binding. *Linguistic Inquiry*, 11:1–46.

Chomsky, Noam. 1981. *Lectures on Government and Binding*. Foris, Dordrecht.

Chomsky, Noam. 1982. *Some Concepts and Consequences of the Theory of Government and Binding*. Linguistic Inquiry Monograph 6. MIT Press, Cambridge.

Chomsky, Noam. 1986a. *Barriers*. MIT Press, Cambridge.

Chomsky, Noam. 1986b. *Knowledge of Language: Its Nature, Origins, and Use*. Praeger, New York.

Chomsky, Noam. 1993. A minimalist program for linguistic theory. In *The View from Building 20: Essays in Linguistics in Honor of Sylvain Bromberger*, edited by Kenneth Hale and Samuel Jay Keyser, pp, 1–52. MIT Press, Cambridge.

Chomsky, Noam. 1995a. Bare phrase structure. In *Government and Binding Theory and the Minimalist Program: Principles and Parameters in Syntactic Theory*, edited by Gert Webelhuth, 383–439. Blackwell, Oxford.

Chomsky, Noam. 1995b. *The Minimalist Program*. MIT Press, Cambridge.

Chomsky, Noam. 2000. Minimalist inquiries: The framework. In *Step by Step: Minimalist Essays in Honor of Howard Lasnik*, edited by Roger Martin, David Michaels, and Juan Uriagereka, pp. 89–155. MIT Press, Cambridge.

Chomsky, Noam. 2001. Derivation by phase. In *Ken Hale: A Life in Language*, edited by Michael Kenstowicz, pp. 1–52. MIT Press, Cambridge.

Chomsky, Noam. 2004. Beyond explanatory adequacy. In *Structures and Beyond: The Cartography of Syntactic Structures, vol. 3*, edited by Adriana Belletti, pp. 104–131. Oxford University Press, New York.

Chomsky, Noam. 2005. Three factors in language design. *Linguistic Inquiry*, 36: 1–22.

Chomsky, Noam. 2007. Approaching UG from below. In *Interfaces + Recursion = Language? Chomsky's Minimalism and the View from Syntax-Semantics*, edited by Uli Sauerland and Hans-Martin Gärtner, pp. 1–18. Mouton de Gruyter, Berlin.

Chomsky, Noam. 2008. On phases. In *Foundational Issues in Linguistic Theory: Essays in Honor of Jean-Roger Vergnaud*, edited by Robert Freidin, Carlos P. Otero, and Maria Luisa Zubizarreta, pp. 133–166. MIT Press, Cambridge.

Chomsky, Noam. 2010. Some simple evo-devo theses: How true might they be for language? In *The Evolution of Language: Biolinguistic Perspectives*, edited by Richard K. Larson, Viviane Déprez, and Hiroko Yamakido, pp. 45–62. Cambridge University Press, Cambridge.

Chomsky, Noam. 2013a. The Dewey Lectures 2013: What kind of creatures are we? Lecture I: What is language? *The Journal of Philosophy*, 110 12: 645–662.

Chomsky, Noam. 2013b. Problems of projection. *Lingua*, 130: 33–49.

Chomsky, Noam. 2015. Problems of projection: Extensions. In *Structures, Strategies and Beyond: Studies in Honour of Adriana Belletti*, edited by Di Domenico, Elisa, Cornelia Hamann, and Simona Matteini, pp. 3–16. John Benjamins, Amsterdam.

Chomsky, Noam. 2017. The language capacity: Architecture and evolution. *Psychonomic Bulletin & Review*, 24 1: 200–203.

Chomsky, Noam. 2019. Some puzzling foundational issues: The Reading program. *Catalan Journal of Linguistics*, Special Issue 2019: 263–285.

Chomsky, Noam, Ángel, J. Gallego, and Dennis Ott. 2019. Generative grammar and the faculty of language: Insights, questions, and challenges. *Catalan Journal of Linguistics*, Special Issue 2019: 229–261.

Déchaine, Rose-Marie, and Martina Wiltschko. 2002. Decomposing pronouns. *Linguistic Inquiry*, 33 (3):409–442.

Embick, David. 2010. *Localism versus Globalism in Morphology and Phonology*. MIT Press, Cambridge.

Emonds, Joseph. 2000. *Lexicon and Grammar: The English Syntacticon*. Mouton, Berlin.

Fitch, W. Tecumseh, Marc D. Hauser, and Noam Chomsky. 2005. The evolution of the language faculty: Clarifications and implications. *Cognition*, 97 (2): 179–210.

Frampton, John, and Sam Gutmann. 2000. Agreement is feature sharing. Ms. Northeastern University.

Gärtner, Hans-Martin. 2002. *Generalized Transformations and Beyond: Reflections on Minimalist Syntax*. Akademie Verlag, Berlin.

Harley, Heidi. 2014. On the identity of roots. *Theoretical Linguistics*, 40(3/4): 225–276.

Hauser, Marc D., N. Chomsky, and W. Tecumseh Fitch. 2002. The faculty of language: What is it, who has it, and how did it evolve? *Science*, 298:1569–1579.

Hornstein, Norbert. 2009. *A Theory of Syntax: Basic Operations and UG*. Cambridge University Press, Cambridge.

Huang, C.-T. James. 1982. *Logical Relations in Chinese and the Theory of Grammar*. PhD thesis, MIT, Cambridge.

Lasnik, Howard, and Juan Uriagereka. 2012. Structure. In *Handbook of the Philosophy of Science, Vol. 14: Philosophy of Linguistics*, edited by Ruth Kempson, Tim Fernando, and Nicholas Asher, pp. 33–61. Elsevier, Amsterdam.

May, Robert. 1985. *Logical Form: Its Structure and Derivation*. Linguistic Inquiry Monograph; 12. MIT Press, Cambridge.

McCloskey, James. 2002. Resumption, successive cyclicity, and the locality of operations. In *Derivation and Explanation in the Minimalist Program*, edited by Samuel David Epstein and Daniel T. Seely, pp. 184–226. Blackwell, Oxford.

Moro, Andrea. 2000. *Dynamic Antisymmetry*. MIT Press, Cambridge.

Muysken, Pieter, and Henk van Riemsdijk. 1986. Projecting features and featuring projections. In *Features and Projections*, edited by Pieter Muysken and Henk van Riemsdijk, pp. 1–30. Studies in Generative Grammar 25. Foris, Dordrecht.

Nunes, Jairo. 1995. *Without Specifiers: Phrase Structure and Events*. PhD thesis, University of Maryland, College Park.

Ochi, Masao. 1999. *Constraints on Feature Checking*. PhD thesis, Storrs: University of Connecticut.

Pesetsky, David. 2000. *Phrasal Movement and Its Kin. Linguistic Inquiry Monograph*; 37. MIT Press, Cambridge.

Pesetsky, David, and Esther Torrego. 2001. T to C movement: Causes and consequences. In *Ken Hale: A Life in Language*, edited by Michael Kenstowicz, pp. 355–426. MIT Press, MIT, Cambridge.

Pesetsky, David and Esther Torrego. 2006. Probes, goals and syntactic categories. In *Proceedings of the 7th Annual Tokyo Conference on Psycholinguistics*, pp. 24–60, Hituzi Syobo, Tokyo.

Pesetsky, David, and Torrego, Esther. 2007. The syntax of valuation and the interpretability of features. In *Phrasal and Clausal Architecture: Syntactic Derivation and Interpretation*, edited by Simin Karimi, Vida Samiian, and Wendy K. Wilkins, pp. 262–294. Linguistik Aktuell 101. John Benjamins, Amsterdam.

Rezac, Milan. 2010. Φ-agree versus ϕ-feature movement: Evidence from floating quantifiers. *Linguistic Inquiry*, 41(3): 496–508.

Rizzi, Luigi. 2015. Cartography, criteria, and labeling. In *Beyond Functional Sequence*, edited by Ur Shlonsky, vol. 10 of *The Cartography of Syntactic Structures*, pp. 314–338. Oxford University Press, Oxford.

Russell, Bertran, and North Whitehead, Alfred. 1913. *Principia Mathematica*. Cambridge University Press, Cambridge.

Sells, Peter. 1985. *Lectures on Contemporary Syntactic Theories: An Introduction to Goverment-Binding Theory, Generalized Phrase Structure Grammar, and Lexical-Functional Grammar*. CSLI lecture notes 3. CSLI, Stanford, Ca.

Sells, Peter. This volume. The view from declarative syntax.

Stabler, Edward. 1997. Derivational minimalism. In *Logical Aspects of Computational Linguistics*, edited by Christian Retoré, pp. 68–95. Springer, Dordrecht.

Starke, Michal. 2001. *Move Reduces to Merge: A Theory of Locality*. PhD thesis, University of Geneva. Available at http://ling.auf.net/lingBuzz/000002.

Svenonius, Peter. 1994. C-selection as feature-checking. *Studia Linguistica*, 48 (2): 133–155.

Taraldsen, Knut Tarald. 1996. How to keep linguists happy: Review of *The Minimalist Program* by Noam Chomsky. *GLOT International*, 2 (3):12–15.

Yang, Charles, Stephen, Crain, Robert C, Berwick, Noam Chomsky, and Johan J, Bolhuis. 2017. The growth of language: Universal Grammar, experience, and principles of computation. *Neuroscience & Biobehavioral Reviews*, 81: 103–119.

Zeijlstra, Hedde. 2008. On the syntactic flexibility of formal features. In *The Limits of Syntactic Variation*, edited by Theresa Biberauer, pp. 143–173. Linguistik Aktuell 132. John Benjamins, Amsterdam.

10

On Chomsky's Legacy in the Study of Linguistic Diversity

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10.1 Introduction

One core topic that is distinctive to linguistics as a discipline is a full-blown engagement with crosslinguistic diversity. We ask, what is there to be learned from the fact that humans currently speak the 7000-odd different languages they do, plus many more that were spoken in the past, and the innumerable different dialects, varieties, and idiolects of the named languages? This is a job for linguists in particular, and a significant piece of what they can contribute to cognitive science and the understanding of human nature more broadly.

Chomsky's contribution to this topic is a bit paradoxical. He has never been known for the diversity of the languages he studied personally. He has perhaps never himself made a prominent empirical discovery about a language other than English – or not since his MA thesis on Modern Hebrew (Chomsky 1951). In reviewing his career, one can – somewhat provocatively – divide it up into three periods: a period of *neglecting* linguistic diversity, a period of *limiting* linguistic diversity, and a period of *denying* linguistic diversity. Nevertheless, the impact that he has had on the substantive study of linguistic diversity has led to its flourishing. This has come about primarily through the concepts and methods that have been internalized by his students and followers, creating a distinctive ethos of inquiry that involves formulating explicit rules and principles, testing hypotheses about how linguistic phenomena interact with one another, and pursuing the distinctive notions of universal grammar and parametric variation. And we should hope that this impact continues as a long-lasting legacy that does not fade anytime soon – despite certain trends in other directions.

Here I explore this somewhat paradoxical legacy through the lens of revisiting three of Chomsky's most influential books, each garnering more than 20,000 citations. These books were published at roughly 15-year intervals, giving snapshots of his earlier, middle, and later thinking on this topic. The "neglect" stage is represented by *Aspects of the Theory of Syntax* (1965). The "limiting" stage is represented by *Lectures on Government and Binding* (1981). I discuss these two stages in more detail. Then, as

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a coda, I touch briefly on the "denial" stage represented by *The Minimalist Program* (1995). For each stage, I give a flavor of Chomsky's ideas relevant to linguistic diversity, and what can be taken away from them in the contemporary scene. The points that I pick out are a blend of what I think the loose-knit community of generative linguists interested in linguistic diversity have internalized from the Chomskyan legacy, what I know I personally have internalized, and what I think the field should try to keep in mind. I also include some passing remarks on how Chomsky's view of these matters contrasts with other views – not systematically or in any depth, but so that what is distinctive about Chomsky's legacy stands out more clearly.

10.2 The "Neglect" Period of *Aspects*

It is well-known that, for approximately 25 years (before about 1980), Chomsky himself did not seem particularly interested in crosslinguistic diversity (see, e.g. Lasnik and Lohndal 2013, p. 49). His major general work from the middle of this period was *Aspects of the Theory of Syntax*. The book's first sentence states, "This study will touch on a variety of topics in syntactic theory and English syntax, a few in some detail, several quite superficially, and none exhaustively." And indeed, the focus on English syntax is maintained throughout. Of the numbered examples, many are bits of linguistic theory – rules or representations – and almost all the rest are examples from English. There is one numbered example from another language. It comes late in the work, it is from French, and it is word-by-word parallel to an immediately preceding English example. The index does not contain a single entry for any particular language. Chomsky never denies interest in languages other than English, but he does not directly model an interest in them, either. That is why it seems fair to call this Chomsky's period of neglect of linguistic diversity.

This was a marked contrast to American linguistics in the earlier twentieth century, which was characterized by an explicit interest in linguistic diversity. Boas and Sapir, coming out of an anthropological tradition, had a great interest in describing the languages of North America, and investigating how different they were from European languages and from one another. Bloomfield, a leader of American structuralism, did extensive work on Algonquian languages and Tagalog. Also heavily engaged in the Linguistic Society of America at this time were members of the Summer Institute of Linguistics, including Pike and Nida, who had practical as well as theoretical interests in studying linguistic diversity. In this context, Chomsky's focus on English seemed like a retrenchment.

But this is looking only at the surface of the matter. There was a very important reason why Chomsky's work of this era was focused so heavily on English. This is because, through the techniques and perspective of generative grammar, he and his associates were making an abundance of new discoveries about English syntax, and he was excited about it. For example, he (1965, pp. 22–23) points out the superficial similarity of the sentences in (1a) and (1b).

(1) a. I persuaded a specialist to examine John.
    b. I expected a specialist to examine John.

He writes:

> The first impression of the hearer may be that these sentences receive the same structural analysis. Even fairly careful thought may fail to show him that his internalized grammar assigns very different syntactic descriptions to these sentences. In fact, as far as I have been able to discover, *no English grammar has pointed out the fundamental distinction between these two constructions* [emphasis mine – MCB].

But then he draws attention to important differences. First, passivizing the embedded clause has very different forces in the two cases: (1b) and (2b) are "cognitively synonymous," whereas (1a) and (2a) have quite different truth conditions.

(2) a. I persuaded John to be examined by a specialist.
b. I expected John to be examined by a specialist.

He then sketches an analysis of the difference, saying that *a specialist* is underlyingly the direct object of *persuade* in (1a), but bears no grammatical relation to *expect* in (1b). He then makes a connection to the fact that *persuade* takes a direct object as well as a finite clause in (3a) but *expect* cannot, as in (3b).

(3) a. I persuaded John [that he should be examined by a specialist].
b. NOT: I expected John [that he should be examined by a specialist].

In current terms, *persuade* is an "object control" verb, whereas *expect* governs "exceptional case marking" or "raising to object." Chomsky put forward many striking and previously unnoticed discoveries of this sort throughout these years and beyond.

What Chomsky was discovering is how vast and complex the grammar of a language is, far beyond what most thinkers in other generations could imagine. He illustrated this primarily in English, but the clear implication was that the same would be true for any natural language. In this way, he inspired others to make similar discoveries in other languages, even from an early date. Newmeyer (1986, 40) points out that four of the six faculty members in MIT's linguistics department in the late 1960s were known primarily for their work on languages other than English, and 17 of 28 PhD dissertations written at MIT in the 1960s were primarily about languages other than English. The point of Chomsky concentrating on English for a time was to enormously raise the bar of what counts as a description of the syntax of a natural language. Only once we begin to have a true appreciation of the splendid complexity of the grammar of particular languages can we grasp the scope and significance of the similarities and differences among these languages.

We cannot overestimate the importance of this discovery of the vastness and richness of syntax for the study of language diversity. Hunt down and open up a pregenerative structuralist-style grammar of a language. Many of them have only a five-page description of the syntax of the language, if that; plenty have none at all. One is lucky if there is even a clear statement about the order of words. With rare exceptions, one gets no sense at all of what the language was really like, or how to speak it. I imagine that the writers of such grammars must have known that there was more to the language than that. I have heard anecdotally that once traditional Iroquoianists had described the complex phonology and morphology of their languages, they were too tired to face the syntax seriously. Perhaps also they did not have the formal tools to describe the syntax adequately. But for whatever reason, the core facts about syntax in the languages of the

world were not getting out. Chomskyan theoretical linguistics has often been contrasted with "descriptive linguistics," and not entirely without reason. But I heartily agree with remarks that Pieter Muysken made at the KNAW Conference on Diversity and Universals in Language, Culture, and Cognition in 2013, when he asserted that the great contribution of Chomskyan linguistics has been to *descriptive* linguistics, as it has discovered a plethora of genuinely new facts about languages and language. I for one have been inspired by the kinds of discoveries that were being made in English and the Romance languages, and wanted to use a similar precision, sophistication, and attention to detail to make discoveries about Mohawk, Edo, Sakha, and Shipibo.

There are important details about Chomsky's conception of the project of generative grammar that undergird this sense of discovery and are worth surveying. One was his use of mathematical techniques like recursive function theory (1965, p. 8), making explicit how language can "make infinite use of finite means" (a favorite phrase of his from Humboldt). It was a revelation how easily one can begin to account for the possibility of sentences of unbounded size and complexity in these terms, once one phrase can be embedded in another of the same kind. A related emphasis was his insistence that grammatical rules be explicit and well-defined, not presupposing common sense. He (1965, p. 4) writes:

> A grammar of a language purports to be a description of the ideal speaker-hearer's intrinsic competence. If the grammar is, furthermore, perfectly explicit – in other words, if it does not rely on the intelligence of the understanding reader but rather provides an explicit analysis of his contribution – we may (somewhat redundantly) call it a *generative grammar*.

Part of the idea here is that only when one takes on the discipline of trying to be precise about the language, the way that a computer programmer would have to be, can one be confident that one has faced all the true complexities of its grammar.

Of special importance is Chomsky's emphasis on how phenomena interact with one another. If two mathematical functions are well-defined, then the compositions of those functions $f(g(x))$ and $g(f(x)))$ are also well-defined. The same should hold for linguistics. If one professes to understand both (say) passivization and question formation, then an excellent test of one's understanding is whether one can correctly predict how to form a question based on a passive. Pursuing this systematically deepens both understanding and description. Often enough, one can make correct predictions about this – a very satisfying feeling. Just as often, one does *not* make correct predictions about this over the whole range of the phenomena. This initial embarrassment is a source of new discovery, a spur to rethink and find the right description of the component parts. This dynamic is at work in (1)–(3) above: something new is revealed by looking at the interaction of nonfinite clausal embedding with passivization. Again, this is not to be taken for granted. Only the very best descriptive grammars pay much attention to interactions. For example, grammars of Bantu languages often describe to some degree the language's passive construction (similar to English's) and its applicative construction (like dative shift in English, but more productive and morphologically marked). But grammars won't necessarily say what happens when one does a passive of an applicative: the language might be a so-called symmetrical object language, where either of the two objects can become the subject of the passive, or an asymmetrical object language, where only one of the objects can become the subject (Bresnan and Moshi 1990). Even worse, most grammars don't tell you explicitly that one cannot

form the applicative of a passive – *except* that one can form a locative applicative (not a benefactive or instrumental applicative) out of a passive in Chichewa (Alsina 1990, ex (13)). Without the discipline of investigating interactions systematically, the description of the language is incomplete, in that the linguist doesn't know things that the competent native speaker does know. Furthermore, the linguist has missed valuable clues to the precise nature of passive, applicative, and the basic structures to which both apply.

Another feature of this conceptual cluster is Chomsky's emphasis on linguistic research being done by native speakers, or in close collaboration with them (1965, pp. 18–21). Chomsky contrasted this to collecting a finite corpus and performing semi-mechanical manipulations over that corpus, or to doing experiments in the style of psychology. Working with native speakers enriches the data that the linguist has to work with and makes the process of discovery more creative (open-ended, responsive to surprises). It is initially only the native speakers who know (tacitly) how passive interacts with clausal embedding or applicative formation, and a great way for linguists to find out is by asking them. Most experiments are, after all, only a more regimented and systematic way of asking the native speakers – and in practice you need to consult them anyway in the course of constructing the experimental materials. As for corpuses, they are by definition finite, and one never knows for sure whether the absence of some complex sentence type in such a corpus is an accidental gap or not. Of course, the corpuses being used now can be vastly larger than those in view in 1965, and the ways of searching them are far more sophisticated, making them a valuable tool. But a corpus is still finite, whereas the generative linguist faces the fact that the structures that a native speaker can produce and interpret are infinite (for most languages, if not all). Therefore, working with such speakers is often the easiest way forward, and the one that fits the case best. Moreover, given that many languages may now have only a handful of fluent native speakers, and work on those languages is urgent for both theoretical and practical reasons, we need methodologies that do not depend on recording a giant machine-readable corpus or having a certain number of speakers capable of doing reaction time experiments. There are, of course, (many!) things that can go wrong with a traditional fieldwork interview. But the solution is to learn to do such interviews better, and to submit the results to processes of checking and refinement, not to abandon the technique. Presumably someday we will be able to move algorithmically from a corpus of a certain kind to a grammar of the language, the way a child does when learning a language according to Chomsky. But that will be a sign that we have essentially finished the task of linguistics, not an effective way to pursue linguistics now in its middle age.

Chomsky is famous for his views about Universal Grammar (UG), which have evolved over the years; I emphasize his later view in the next section. However, one positive consequence of any such view, as emphasized already in *Aspects* (1965, p. 41), is that it makes the study of any one language or construction relevant in principle to the study of any other language or construction. The reason is simple: what you learn about language X can help you infer something about UG, because language X is a manifestation of UG under certain conditions. This improved understanding of UG is then relevant to the study of language Y, putting new boundary conditions

on its analysis. This is of great sociological importance, because it means that the researcher into some obscure language can be as much a part of a grand overall project as researchers working on better-known languages. Indeed, a researcher working on some small local language might have an advantage, if some UG phenomenon happens to be manifested more transparently in that language, for whatever reason. Other linguistic approaches tend to deny any serious notion of UG, sometimes even repudiating it as an ethnocentric, quasi-imperialist imposition on other languages. A result is that non-Chomskyan approaches tend to study languages in isolation, or in genetic families and areal groups, often not citing works in other areas (although typological works in the tradition of Greenberg 1963 are a partial exception). Generative grammar's notion of UG creates a larger potential audience for work on various languages and valuable sources of cross-fertilization. It is true that, in the early days, the flow of influence was primarily in one direction, with a tendency to analyze (say) Japanese in the light of English, rather than the other way around. But that was arguably just because English happened to be the first language to be studied more deeply in the generative style. There is no intrinsic asymmetry in Chomsky's conception, and I believe that we are now in a more egalitarian era, where insight from one language flows more freely to others in any direction. As one example among many, Pesetsky (2013) uses Richards's (2013) analysis of case-stacking in the Australian language Lardil as a basis for his new analysis of case in a major Indo-European language (Russian).

The last aspect of Chomsky's early vision that I review here is his long-standing insistence on language acquisition as putting a boundary condition on linguistic theory, including the theory of linguistic diversity. The crucial empirical fact is that "evidently the child is not predisposed to learn one language rather than another" (1965, p. 26). This is abundantly clear in our contemporary world, where children from all over the Earth (putting aside certain genetic disorders) learn perfect American English when they grow up in America. This is another touch point regarding linguistic diversity that has salutary benefits. Suppose one finds a surprising emergent property when looking at complex sentences from a less-studied language, as one often does. Somehow children learning the language acquired that property, without thinking so hard about such complex sentences. Therefore, one of two things must be true, according to Chomsky. First, that property could be part of UG itself, such that the child did not have to learn it at all. Then it must hold true of other languages too (in some form, shaped by interaction with those languages' specific properties), putting a substantive bound on crosslinguistic diversity. Alternatively, that feature could be a consequence of some simpler feature of the language – something that children can detect in simple sentences that they are sure to be exposed to – in interaction with other properties, language specific or general. This is a spur to studying languages as interrelated wholes, where complex properties are organically related to simpler properties in interesting ways. This is a very different vision that that of (say) Construction Grammar, in which languages can be more or less random grab-bags of unrelated constructions and properties. The Chomskyan vision is more interesting, and ultimately more fruitful, I believe.

In summary, Chomsky's early seeming neglect of crosslinguistic diversity was a tactical move that has served the study of linguistic diversity very well. It gave an inspiring new picture of what the syntax of any language is like and developed a conception of linguistic theory within which the deep study of languages could thrive.

10.3 The "Limiting" Period of *LGB*

Let us move ahead, then, to the so-called Government and Binding (GB) or Principles and Parameters (P&P) phase of Chomsky's work, with *Lectures on Government and Binding* (1981) (*LGB*) as its flagship expression. This is the period in which Chomsky's most specific hypotheses about linguistic diversity took shape, including his mature notion of UG and the key idea of the parameter as the unit of syntactic diversity. Since these are concrete hypotheses, there is naturally more controversy about them, even within the generative community – even, it seems, in Chomsky's own mind. But they are game-changing ideas, so part of Chomsky's legacy, even as our precise understanding continues to evolve.

By superficial metrics, it is clear that language diversity is front-and-center in the program of *LGB* in a way that it was not in *Aspects*. Whereas *Aspects* had zero languages listed in its index, *LGB* has 22. Most of them are major Western Indo-European languages, but there are also other languages of Europe (Finnish, Hungarian) or in fairly close contact with Europe (Turkish, Arabic, Hebrew), some major languages from Asia (Japanese, Korean, Chinese, Malayalam), and a smattering of more "exotic" languages (Navajo, Yoruba, Warlpiri). While this representation is modest and biased by the standards of twenty-first century Typology, whether functionalist or generative (e.g. Cinque 1999; Baker 2008b), the change is striking. One sees the generative program widening in concentric circles from its epicenter in English, as a critical mass of generative analyses begins to accumulate. Chomsky's student Kayne did work on French of comparable sophistication to Chomsky's on English (Kayne 1975, etc.), and taught a cadre of generative linguists in France. This included the young Luigi Rizzi, who began similar work on Italian (Rizzi 1982). Fascinating patterns of difference and similarity began to emerge from the close comparison of even just these three languages, which *LGB* takes up. Talented native speaker linguists came to MIT to work on Hebrew (Borer), Arabic (Aoun), Chinese (Huang), Japanese (Saito), and others. MIT hired Ken Hale, who brought with him an intimate encounter with Navajo, Jemez, Hopi, Tohono O'odham, and Warlpiri, and who opened up opportunities to do fieldwork on interesting languages for generations of MIT students. Perlmutter and Postal created Relational Grammar (e.g. Perlmutter 1983), an alternative form of generative grammar in which grammatical relations are not defined over phrase structure, an innovation intended to make it work for languages with different word order properties, and their students achieved impressive results in a wide range of languages. In response, Burzio, Marantz, and Baker endeavored to bring the kinds of results that Relational Grammar achieved back into the Chomskyan mainstream. *LGB* has comments on all these developments, as Chomsky's vision burgeoned outward toward a fuller engagement with language diversity.

In part, this activity was the accelerating process of Chomsky's original vision of generative grammar bearing fruit over time, building up a critical mass of results. But two distinctive new ideas emerged in Chomsky's thinking that are very relevant to the study of linguistic diversity: the vision of UG as a system of principles that constrain the otherwise free formation of linguistic structures and the idea of a limited amount of parametric variation in those principles. These are contentful empirical hypotheses at the highest level. Therefore, Chomsky (1995, p. 5) writes, retrospectively, of the shift from early generative grammar to P&P as being more profound and radical than the shift from traditional grammar to early generative grammar.

An idealized history of the line of inquiry that led to principles of UG goes like this. First, there was "immediate constituent analysis," the notion that sentences and phrases are built up out of smaller phrases – a pre-Chomskyan idea. Then added to this was the idea that some of these phrases can move to new positions in various ways – the early Chomskyan notion of a transformational grammar (built on work by Zellig Harris). Next was added the idea that human language puts general constraints on what these transformations can do, which restrict the application of any transformation; Ross's (1967) famous island conditions were a paradigm-forming case in point. As more became known about this, two exciting consequences came into view. One was that maybe one doesn't have to say nearly as much about the transformations as before; if the constraints are rich enough, then the transformations can reduce to "Do anything" (Chomsky's proto-transformation "Move-alpha"), as long as the constraints are not violated.

The second exciting result is that the constraints appear to be far more universal than the transformations and the phrase structures that they seem to depend on. For example, English moves both question words and topicalized phrases to the front of the sentence, whereas Chinese moves only topicalized phrases, leaving question words in-situ – a difference in the transformations (Huang 1982). However, both languages obey Ross's island conditions (more or less) for those phrases that happen to move. See also the discussion of Mohawk versus English below for another example of how very different-seeming languages can obey the same UG principles.

These UG principles seem like the opposite of crosslinguistic diversity, but they have contributed greatly to its study. A belief in this sort of UG means that one can dive into complexities of a new language more boldly, being reasonably confident that some of what one knows from other languages will be applicable. Kayne (2005, p. 8) has argued that the best way to study syntactic diversity is to move relatively slowly, bit by bit – Italian dialect by Italian dialect. The idea behind this is to control for the effects of wild and unforeseen crosslinguistic variation by taking advantage of the naturally existing controlled experiments provided by history, where the benefits of one village being able to talk to the next prevent too many principles from varying at once. This has proved to be a valuable methodology, and perhaps it would be the only viable method in the absence of a strong UG. But with a set of UG principles in the background, it is less necessary to proceed in this more cautious way. Languages do not (it seems) vary chaotically in all respects simultaneously. This makes it feasible to compare them sooner rather than later – not downplaying the differences, but knowing that some things will necessarily be held constant. The successes of proceeding in this way seem to validate the assumption that it is based on. For example, Baker (1996) fills out his study of Mohawk syntax by comparing Mohawk to unrelated and less-studied languages around the world (Southern Tiwa, Nahautl, Mayali, Chukchi, Ainu), arguing that they form a polysynthetic type – very different from English on the surface, but not so different from one another at a top-level of grammatical organization.

Along with the notion of UG as a set of principles came the famous – and somewhat controversial – idea of the parameter. This idea, originally born from close comparison of English, French, Italian, and Spanish in the late 1970s, is that some of UG's principles come in more than one version, and particular languages can pick which version to employ. Early examples were: the head parameter, governing whether heads come before their complements (English) or after them (Japanese); a bounding parameter, governing which phrases an interrogative phrase like *who* can move out of (English vs Italian); an

overt movement parameter, governing whether question words move to a position defining their scope visibly (English) or only as part of constructing Logical Form (Chinese). The most famous was the pro-drop parameter, which distinguished English and French from Spanish and Italian in a cluster of ways having to do with whether an overt subject is required in the preverbal position or not (yes in English and French; no in Italian and Spanish). Significant parts of *LGB* debate the virtues of different ways of formulating this particular parameter. *LGB* also includes some discussion of a potentially more radical parameter that defines whether a language is *configurational* (has a syntax based on phrase structure), interacting with work by Ken Hale on Warlpiri, Japanese, and other languages (see Hale 1983).

One upshot of this view, which Chomsky (1981, p. 11) emphasizes in a characteristically provocative fashion, is that crosslinguistic diversity in syntax must be finite. If the P&P view is right, and there are *n* parameters with *m* settings each, then there are "only" m^n possible human languages from the syntactic point of view (not counting lexical differences and phonological differences). At this this stage, then, Chomsky hypothesizes that there are strong limits on the range of crosslinguistic diversity, which is bounded by both the invariant principles and by the restricted number of parameters.

The practical upshot of this claim is a bit uncertain. Finite does not necessarily mean small, and combinatorial explosion arises quickly. All things being equal, it would only take 13 parameters with two settings each (assuming independence) to give 8192 different syntaxes, outstripping the number of human languages currently spoken. Probably if there are parameters at all, there are a good deal more than that; see Kayne (2005, p. 14) for an estimate of 100, which he considers conservative.

To my mind, what is important about the idea of a parameter is not so much that linguistic variation is finite, but that it is patterned, such that there are interlocking consequences to the crosslinguistic variation that we see. Part of the *LGB* idea of a parameter was the notion of a parametric *cluster*: a range of visible effects that choosing one parameter setting rather than another can have. For example, the notion that Italian/Spanish but not French/English allow the canonical subject position to have no overt occupant not only had the relatively direct consequences that one says in Italian "rains" rather than "it rains" and "arrives" rather than "she arrives," but also the more subtle consequences that one can say in Italian "arrives Maria," "Who do you think that arrived?" and even "the man who I wonder who saw," which is well-nigh uninterpretable in English. These larger-scale patterns in crosslinguistic variation are fascinating in their own right, and of great importance for linguistic theory and the theory of language acquisition. This again points to a view in which a language's particular features may be interconnected in various ways.

The power of these ideas for understanding even radical linguistic diversity can be illustrated by a schematic summary of my generative analysis of the Mohawk language (Baker 1996). Mohawk is a so-called polysynthetic language with nonconfigurational characteristics, very different in many ways from English. (4) gives a selection of English word-by-word glosses for Mohawk examples that give the flavor of this. (The pronoun subject is in parentheses because it would normally be omitted in Mohawk, as in Italian and Spanish.) The object in Mohawk can follow the verb, as in English ((4a)). However, it can just as well come before the verb ((4b)), or be left out altogether ((4c)). (This is the "nonconfigurational" aspect of Mohawk.) Mohawk also differs from English in more subtle ways that it takes a generative linguist to notice. Thus, it does not allow nonreferential quantified objects ((4d)), it does not allow one to question a proper subpart of the

object, the way English sometimes does ((4e), compare *Who did he enjoy the story about?*), and it does allow a subject pronoun to refer to a person who is named as the possessor of the direct object ((4f)).

(4) a. (He) likes fish.
b. (He) fish likes.
c. (He) likes.
d. *NOT*: (He) likes nothing.
e. *NOT*: Who (he) likes [story —]?
f. (He) likes [John's shirt]. OK with meaning he = John

Mohawk is thus very different from English in a wide range of ways, and we can ask why.

I claim that there is a surprisingly simple answer. Many familiar European languages have affixes on the verb that express agreement with the subject. As a polysynthetic language – a language with complex words made up of many parts – Mohawk also has this kind of affix, but it takes this one step further: Mohawk's verbs have prefixes that agree with both the subject and the object. For example, one way to say "likes" is *ranuhwe's*, where the prefix *ra-* shows that the subject is third person masculine singular ("he") and the object is third person neuter singular ("it"). Now I introduce a theoretical hypothesis: that the object agreement prefix in Mohawk is syntactically equivalent to a direct object pronoun like *it* in a language like English. If that is so, then we should add this "it" to our schematic Mohawk sentences in (4). This gives sentences like (5) (with some minor adjustments).

(5) a. He likes it, this fish.
b. This fish, he likes it.
c. He likes it.
d. *NOT*: He likes it, nothing.
e. *NOT*: Who does he like it, [the story about —]
f. [John's shirt], he likes it. OK with meaning he = John

Remarkably, the grammaticality of this set of examples, taken as real English sentences, is point-by-point the same as the grammaticality of the corresponding Mohawk sentences reported in (4). (5a) in English is a so-called object dislocation sentence (cf. Cinque 1990); it is a bit stilted and more part of conversational language than written language, but possible. (5b) shows that the dislocated object can come at the beginning of the sentence rather than at the end, as long as the pronoun 'it' stays in the canonical object position immediately after the verb. (5c) shows that the dislocated object can be left out entirely, leaving only the pronoun. (5d) shows that a nonreferential quantifier cannot be dislocated in this way. (5e) shows that one cannot move a question word out of a dislocated object in English. Finally, (5f) shows that a pronoun subject can refer to a name inside a dislocated object. These grammaticality patterns (particularly (5d–f)) are explained by the invariant principles of UG in the P&P framework – principles like weak crossover ((5d)), the Condition on Extraction Domains ((5e)), and Condition C of the Binding theory ((5f)). Now we can say that these conditions hold in Mohawk too. However, there is a twist to how they apply: because of Mohawk's polysynthesis, verbs always contain an object pronoun, so simple sentences in Mohawk correspond to

dislocated-object sentences in English rather than to ordinary object-in-situ sentences in English. One can say that Mohawk is really only different from English in one way, but that difference has wide-ranging repercussions because of how other invariant principles apply. This gives a fuller taste of how the same UG principles might apply to very different languages. It also shows how one parameter of variation can have a range of effects, accounting for patterns in crosslinguistic variation. Finally, it shows how surface properties of a language that would be present in any description (like free word order) can be closely interrelated with more complex and subtle properties (like a peculiar pattern of question formation), as Chomsky's views about language acquisition imply must be the case.

There are currently many technical questions about parameters, concerning what they are exactly, how many of them there are, and what grain they have. Perhaps not surprisingly, the initial parameters of *LGB* have turned out to be more complex than originally thought, as a wider range of languages has been investigated. One prominent view is Kayne's (2005), who argues that Chomsky's initial conception of parameters was essentially correct, but it should be implemented at a finer grain: syntax consists of many small-scale microparameters rather than a medium number of medium-sized parameters. (This view is very similar to the Borer-Chomsky Conjecture mentioned below.) In contrast, I have argued (Baker 2008a) that top-level linguistic typology can be derived from a few largescale "macroparameters" (e.g. the original head-directionality parameter, my polysynthesis parameter just sketched), but the edges of these otherwise discrete types are blurred by the presence of plenty of Kaynian microparameters, which also exist. An interesting intermediate view, developed in different ways by Biberauer, Holmberg, Roberts, and Sheehan in various combinations, is the idea that parameters are strictly local to a single category (microparameters), but if one category in a language has a particular parametric property, then other categories are more likely to have that property as well, resulting in macroparametric tendencies (see, for example, Holmberg and Roberts 2014, p. 68). Structuring how this happens makes it possible to find second-order patterns within the erstwhile exceptions to the first order typological patterns of classical parameter theory, as this team has shown in their study of word order (Sheehan et al. 2017). See Sheehan (Chapter 11 this volume) for much more detailed discussion of specific contemporary notions of parameters.

One thus cannot say that the precise legacy of this cluster of ideas from Chomsky's *LGB* period is entirely clear at this point. But it has been a fascinating and productive new view about what language diversity could be, which has driven the field forward. My money is on the bet that there is something of lasting importance to it.

10.4 The "Denying" Phase of *The Minimalist Program*

I close with some brief discussion of how the most recent phase of Chomsky's research, inaugurated by *The Minimalist Program* (1995), affects his legacy in the study of linguistic diversity. Here there are not many new ideas to discuss. Rather the main question is whether Chomsky abandons the distinctive P&P vision about the nature of language diversity as he moves toward the Minimalist Program. My claim is that he does not retract this vision in any fundamental way, although he does shift his focus to a different topic.

By superficial metrics, *The Minimalist Program* looks more like *Aspects* than like *LGB*. The number of languages cited in the index has returned to 0, and in the last two chapters there are nine numbered examples from languages other than English out of 272 total examples over 228 pages of text. Moreover, Chomsky's explicit comments about language diversity, which were always provocative, become even more dramatic. He (1995, p. 7) begins floating the idea that there may be, in some important sense, only one human language – that is, one computational system, called C_{HL}, which builds syntactic representations for the conceptual-intentional system to interpret. All crosslinguistic differences are tentatively attributed to differences in the features and properties of lexical items, especially functional heads. (These features have syntactic effects because they may or may not trigger movement, or deletion of their complement, or similar operations.) Chomsky (1995, p. 170) thus writes:

> If [this is] so, there is only one computational system and one lexicon, apart from this limited kind of variety. Let us tentatively adopt that assumption – extreme, perhaps, but it seems not implausible – as another element of the Minimalist Program.

This view is sometimes called the Borer–Chomsky Conjecture, recognizing its roots in Borer 1984. This shift in perspective fits naturally with the increased use of features in driving syntactic derivations within the Minimalist Program; see Alexiadou and Lohndal (this volume) and Sheehan (this volume) for discussion. It is a point of debate whether this amounts to a new theory of what parameters are or a rejection of the original notion of a parameter.

Indeed the classical notion of a parameter sits a bit uncomfortably with some other aspects of the Minimalist Program. For example, if there are fewer core principles of UG than *LGB* imagined, then there are also fewer things to parameterize. Furthermore, parameters do not seem to be "virtually conceptually necessary" for a system of natural language – the gold standard for a Minimalist analysis. It is also not clear why or how parameters should have evolved as part of the human language faculty, a consideration that Chomsky pays more attention to in the Minimalist Program. Therefore, Chomsky himself is somewhat ambivalent about the P&P vision of linguistic diversity in his recent work – even as he continues to endorse the P&P-style theory of Charles Yang, as pointed out by Newmeyer (Chapter 18 this volume). And some other Chomskyan linguists have pushed this Minimalist critique of P&P more strongly.

As a Chomskyan linguist who has taken up the study of linguistic diversity as a major part of my life work, I understand this differently. I take Chomsky not to be retracting the early generative and P&P project regarding language diversity as much as inaugurating a new project: the project of finding the ideal (minimal) axiomization of (something like) the GB principles and parameters, which gives the same kind of results with fewer basic assumptions. This includes a lessened interest in studying linguistic diversity himself – or perhaps a sense that this is not where he can best contribute at this stage of his career (and given the pursuit of his other interests). However, if a theoretical framework's degree of explanatory force can be measured very roughly as the ratio of the empirical facts that it brings under analysis to the theoretical assumptions it makes use of, then there are two ways to increase its degree of explanation: one can try to increase the facts-under-analysis, or one can try to reduce the theoretical assumptions being made. The second approach has been Chomsky's own emphasis in this recent phase, and that of the "hard-core" Minimalists. But the first approach remains a valid way of contributing to the same general enterprise. It is valid work, too – and in practice, there is more

work for a range of linguists within the first approach than within the second, there being thousands of languages to work on and only a limited number of conditions to derive from first principles.

And, indeed, generative work on linguistic diversity continues robustly. This can be seen easily by looking at the range of languages discussed in recent dissertations from MIT, or in recent *Linguistic Inquiry* monographs, or in recent articles in *Natural Language and Linguistic Theory*. The range of languages that this type of linguistics is engaging is clearly greater than ever before.

I conclude, then, that it is good to be studying language diversity in a Chomskyan vein, using at least the *Aspects* vision of what a generative grammar is, and probably also some descendent of the *LGB* conception of universal principles and discrete units of patterned variation (parameters) operating within in the context of those principles. If you are told otherwise by either a hard-core Minimalist or an anti-Chomskyan functionalist-inspired descriptive linguist, I suggest that you politely ignore them. Or better yet, turn the conversation gently to some fascinating new pattern that you have discovered recently in some language you are studying.

References

Alsina, A. 1990. Where's the Mirror Principle? *Paper presented at Generative Linguistics in the Old World 13*, Cambridge: Cambridge University.

Baker, M. 1996. *The Polysynthesis Parameter*. New York: Oxford University Press.

Baker, M. 2008a. The macroparameter in a microparametric world. In *The Limits of Syntactic Variation?*, edited by T. Biberauer, 351–374. Amsterdam: John Benjamins.

Baker, M. 2008b. *The Syntax of Agreement and Concord*. Cambridge: Cambridge University Press.

Borer, H. 1984. *Parametric Syntax: Case Studies in Semitic and Romance Languages*. Dordrecht: Foris.

Bresnan, J., and L. Moshi. 1990. Object asymmetries in comparative Bantu Syntax. *Linguistic Inquiry*, 21:147–185.

Chomsky, N. 1951. *The Morphophonemics of Modern Hebrew*. Master's Thesis, University of Pennsylvania.

Chomsky, N. 1965. *Aspects of the Theory of Syntax*. Cambridge: MIT Press.

Chomsky, N. 1981. *Lectures on Government and Binding*. Dordrecht: Foris.

Chomsky, N. 1995. *The Minimalist Program*. Cambridge: MIT Press.

Cinque, G. 1990. *Types of A-bar Dependencies*. Cambridge: MIT Press.

Cinque, G. 1999. *Adverbs and Functional Heads: A Cross-linguistic Perspective*. New York: Oxford.

Greenberg, J. 1963. *Universals of Language*. Cambridge: MIT Press.

Hale, K. 1983. Warlpiri and the grammar of nonconfigurational languages. *Natural Language and Linguistic Theory* 1:5–49.

Holmberg, A., and I. Roberts. 2014. Parameters and the three factors of language design. In *Linguistic Variation in the Minimalist Program*, ed. C. Picallo, 61–81. Oxford: Oxford University Press.

Huang, C.-T. 1982. *Logical Relations in Chinese and the Theory of Grammar*. PhD dissertation, MIT.

Kayne, R. 1975. *French Syntax: The Transformational Cycle*. Cambridge: MIT Press.

Kayne, R. 2005. Some notes on comparative syntax, with special reference to English and French. In *The Oxford Handbook of Comparative Syntax*, edited by G. Cinque and R. Kayne, 3-69. New York: Oxford University Press.

Lasnik, H., and T. Lohndal. 2013. Brief overview of the history of generative syntax. In *The Cambridge Handbook of Generative Syntax*, edited by M. den Dikken, 26–60. Cambridge: Cambridge University Press.

Newmeyer, F. 1986. *Linguistic Theory in America*. New York: Academic Press.

Pesetsky, D. 2013. *Russian Case Morphology and the Syntactic Categories*. Cambridge: MIT Press.

Richards, N. 2013. Lardil "Case Stacking" and the Timing of Case Assignment. *Syntax* 16:42–76.

Perlmutter, D., ed. 1983. *Studies in Relational Grammar 1*. Chicago: University of Chicago Press.

Rizzi, L. 1982. *Issues in Italian Syntax*. Dordrecht: Foris.

Ross, J. 1967. *Constraints on Variables in Syntax*. PhD dissertation, MIT.

Sheehan, M., T. Biberauer, I. Roberts, and A. Holmberg. 2017. *The Final-Over-Final Condition: A Syntactic Universal*. Cambridge: MIT Press.

11

Parameters and Linguistic Variation

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11.1 Introduction

This chapter examines Chomsky's influence on the modeling of linguistic variation, focusing specifically on the notion of parameter (see also Baker, this volume, who discusses Chomsky's more general contribution to the study of linguistic diversity). I begin by examining the different conceptualizations of "parameter" in Chomsky's work, from the Government and Binding (GB) era, through early Minimalism to more recent approaches which locate variation in phonological form (see also Alexiadou & Lohndal, this volume, for a more general theoretical overview). Two domains of variation (word order and argument expression) are then used as case studies to illustrate how Chomsky's ideas have given rise to different kinds of parametric models. Finally, I discuss some of the potential objections to the concept of parameters before concluding.

11.2 Parameters: An Evolving Notion

Chomsky has often pointed out that it is a minimal requirement that a theory of grammar should "be compatible with the diversity of existing (indeed, possible) grammars" and "be sufficiently constrained in the options it permits so as to account for the fact that each of these grammars develops in the mind on the basis of quite limited evidence" (Chomsky 1981, 3). For a long period of time, Chomsky argued that the best way to navigate this tension was via a model consisting of both *principles* and *parameters*. Essentially, his proposal was that, in addition to invariant *principles* of UG, which are common to all human languages, there are also *parameters* of variation, set during acquisition, which determine the differences between languages. The idea that grammatical variation should be modeled by abstract parameters is arguably one of Chomsky's most important contributions to linguistic theory, and one which has had significant influence (as Baker, this volume, also notes). In this section, I discuss the

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evolution of the *Principles and Parameters* approach in Chomsky's own work, before turning to specific examples of parametric models and discussing further innovations in this field as well as some of the objections to this tradition.[1]

The *Principles and Parameters* model was first developed in Chomsky's Pisa lectures which are published as *Lectures on Government and Binding* (*LGB*, Chomsky 1981), a momentous work which is empirically extremely rich as well as highly technical in its implementation. This is the beginning of what Baker (this volume) terms the *restricting* period of Chomsky's approach to linguistic diversity. A major focus of *LGB* is indeed making what were then held to be fundamental abstract principles of UG (such as The Empty Category Principle) compatible with the variation attested across a number of (by then) well studied (mainly European) languages (for example, differences in extraction possibilities and argument expression in Italian vs. English). The way that Chomsky does this is to introduce *parameters* – abstract choice points, set during acquisition – which determine a cluster of surface grammatical properties in their interaction with the principles of UG, in the following way:

> The language learner equipped with the theory of UG as a part of the initial state requires evidence to fix the parameter and then knows the other properties of the language that follow from this choice of value. (Chomsky 1981, p. 241)

This proved to be a highly attractive idea. The GB notion of parameter addressed the poverty of the stimulus issue: the fact that our complex end-state knowledge of a language seems to be drastically underdetermined by the data to which we have been exposed. The proposed solution was that language acquisition was guided by parameters and that these parameters could be set on the basis of one kind of data but then determine a cluster of distinct grammatical properties, some of which may be less obviously acquirable on the basis of positive evidence alone (see Thornton and Crain, this volume, on the poverty of the stimulus and the issue of positive and negative evidence in acquisition). The language acquisition task was further simplified by Chomsky's proposal that there was a finite set of such parameters, given by UG, yielding a finite set of potential grammars.[2] On this view, in acquiring a language, a child is essentially narrowing down from the set of potential grammatical systems made possible by UG to those consistent with the data to which they have been exposed.[3]

Finally, it is worth noting that, despite their central explanatory role, Chomsky remains open minded regarding the actual format of parameters in this early conception. For example, in his discussion of the pro-drop parameter, which distinguishes *non-pro-drop* languages like English and French (1a) (which require an overt subject in finite clauses) from *pro-drop* languages like Italian (1b) (which do not), Chomsky entertains many different possibilities, assessing and rejecting them on empirical grounds.

(1) a. Il pleut.
It rains
b. Piove.
rains
"It is raining/rains."

For example, Chomsky entertains, but rejects, the idea that the rich agreement in Italian-style languages has the ability to fully fulfil the subject function. The problem

for this proposal is that, as Rizzi (1979) had already shown, the preverbal position in pro-drop languages displays certain properties akin to those observed in non-pro-drop languages:

(2)	a.	*Non	voglio	che	nessuno	venga.
		NEG	want.1SG	that	nobody	come.SUBJ
	b.	Non	voglio	che tu	parli	con nessuno.
		NEG	want	that you	speak.SUBJ	with nobody
		"I don't want you to talk to anyone."				(Chomsky 1981: 237, citing Rizzi 1979)
	c.	Non	voglio	che	venga	nessuno
		NEG	want.1SG	that	come.SUBJ	nobody
		"I don't want anyone to come."				(Chomsky 1981: 253, citing Rizzi 1979)

What (2) is taken to show is that even Italian, a pro-drop language, places additional restrictions on preverbal subjects (2a), as compared with objects (2b) and post-verbal subjects (2c). More specifically, a negative concord item in an embedded clause that needs to be licensed by negation in the higher clause seems to be able to form this dependency in (2b-c) but not in (2a). If this dependency is taken to involve movement of some kind, then Italian, like English, seems to display restrictions on moving from the preverbal subject position, something usually handled by the ECP. If the verbal morphology in Italian functioned as the subject, we would not expect to see these effects in Italian.

As Baker, this volume, also notes, much of LGB is dedicated to exploring the empirical predictions of quite different formulations of the pro-drop parameter. This raises an important point about Chomsky's contribution to linguistic theory, which is not well understood outside of generative grammar: the tentative and empirically driven nature of his theory building. One of the great things about LGB, which makes it somewhat difficult to read but also useful for generative researchers, is the back-and-forth manner in which it is written. Chomsky does not present a neat and tidy theory of grammar. Rather, he presents data sets first and then illustrates several (and at times, multiple) ways in which to account for these data, making what he takes to be reasonable assumptions. Then, new data are introduced and work on other languages is interleaved with the discussion of English to test out the empirical predictions of his proposals. Although this can certainly make LGB difficult to read (at times), it provides an invaluable insight into Chomsky's process of theory creation. Chomsky is quick to admit where he has been wrong, too, and where other scholars have advanced empirical or theoretical arguments against his own analyses. This is how theory creation works in a new field of inquiry: it is a group effort and it operates on the principle that the ground is forever shifting, to accommodate new data and generalizations. This has made Chomsky (and generative grammar) many enemies, unfortunately, as there is a perception that the theory never stands still. This is a necessary evil, however. Chomsky's own work, as far back as LGB, clearly shows that theories are for testing and developing, not for reifying.

In the LGB approach, the fact that parameters can take these different kinds of formats follows from the assumption that they are specified as part of UG, the format of which is assumed to be fairly rich and complex. Ultimately, the parameter which Chomsky posits to explain *pro-drop* concerns the way that agreement markers

(e.g., first-person plural *-amos*) are lowered onto verbs in forms like *amamos* "we love" (Spanish). In Italian/Spanish, he claims, this happens early, in the syntax, meaning that the subject position is ungoverned in the syntax and can house the kind of empty subject PRO found in non-finite clauses even in non pro-drop languages ([I want [PRO to leave]]), whereas in English/French it happens later, at LF, meaning the subject position is governed in the syntax and so needs an overt subject, making finite clauses different from non-finite clauses in this respect. This kind of complex inter-modular parameter is not compatible with some later conceptualizations of parameters, as we shall see below, but it serves to explain the data in (1)-(2), as well as Italian's pro-drop properties, by assimilating Italian finite clauses to English non-finite clauses. In sum, the LGB kind of parameter was essentially an open-ended principle of UG, set on the basis of experience. This offered, for the first time, a theory which accommodated both universal properties of language and cross-linguistic variation.

Whilst *The Minimalist Program* (*TMP*, Chomsky 1995) is explicitly taken by Chomsky and others to be a continuation of the *Principles and Parameters* approach, the presentation of parameters is rather different in the four chapters of this work (which actually represent Chomsky's evolving thinking from 1988 onward). In the introduction, for example, citing Borer (1984) and Fukui (1986, 1988), Chomsky (1995, p. 6) briefly mentions what has become a widely adopted proposal regarding the status of parameters, which I henceforth call the *Borer conjecture*:[4]

(3) The Borer conjecture
Parameters reduce to differences in formal features of functional heads.

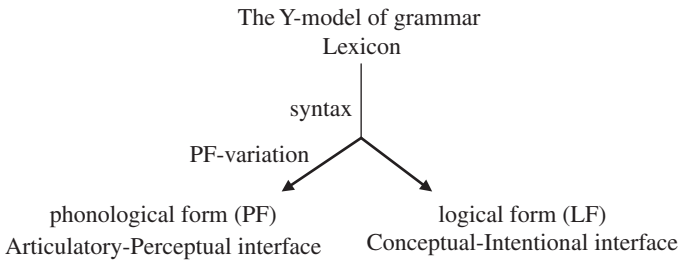
A widely shared idea in Minimalist approaches is that all operations are driven by the formal features of lexical items and so the functional lexicon essentially drives the syntax (where functional lexical items include such things as the articles *the/a*, auxiliary verbs *have/be* and complementisers *that/for* as well as more abstract heads like *T(ense)*). In these terms, parameter setting is simply acquisition of functional vocabulary items, complete with their formal features, as Borer (1984) notes. This rather different notion of parameter retains (at least some of) the afore-mentioned advantages of *LGB* parameters, whilst constraining their format somewhat. If the inventory of possible features and functional heads is also regulated by UG, then the idea that there is a finite set of parameters and grammars is retained, as is, to some extent, the view of acquisition as a process of "narrowing down".[5] The clustering of properties is also retained inasmuch as a single featural difference can have multiple surface effects (as discussed below in relation to the pro-drop parameter). While it is impossible to speak of a single Minimalist concept of parameters, as this program is still evolving, this is, I would argue, the most widely assumed definition of parameter in generative grammar today. It is not true to say, however, that this notion of parameter has completely replaced the LGB notion, as Baker (this volume) also notes.

Chomsky's own thinking regarding parameters has, however, developed further since these early Minimalist ideas. The leading idea in the Minimalist Program is that universal grammar should be pared down to a minimum. Chomsky has explored this idea in ever more radical terms in collaboration with scholars from neighbouring academic disciplines. Berwick & Chomsky (2011), for example, who build on Hauser, Chomsky and Fitch (2002), propose a rather different solution to the apparent problem of linguistic variation:

> Parameterization and diversity, then, would be mostly – possibly entirely – restricted to externalization. That is pretty much what we seem to find: a computational system efficiently generating expressions interpretable at the semantic–pragmatic interface, with diversity resulting from complex and highly varied modes of externalization which, furthermore, are readily susceptible to historical change (Berwick and Chomsky 2011: 37–38)

Essentially, the idea seems to be that, if we take seriously the proposal that language evolved via a single genetic mutation, then we are forced to a fairly simple version of universal grammar with few or no principles or parameters. According to Berwick and Chomsky, there is no obvious place for parameters in such a theory and so variation must be (largely) pushed out of the syntax and into the externalization component (see also Boeckx 2014 for discussion). This assumes the model of grammar referred to as the Y-model whereby the lexicon feeds the syntactic derivation, which gives rise to a phonological form and logical form. In its strongest version, the claim is that all variation across languages happens after the derivation branches into phonological and logical form, on the way to the Articulatory-Perceptual interface (i.e. on the bottom left branch of the diagram):

(4)



I call this approach to variation the "PF-parameter approach" for ease of reference, as it locates the variation in the phonological form component of language in (4), though it is not actually clear whether the proposal is that variation in externalization would be regulated by parameters.[6] In this kind of conceptualization, then, taken to its logical conclusion, there is no syntactic variation and all parameters, to the extent that they exist, actually concern only the morphophonological forms of languages.

The PF-parameter approach shares some properties with earlier Minimalist approaches to parameters. On both conceptions, parameters are no longer specified by UG but rather emerge precisely because there are aspects of language left underspecified. On early Minimalist approaches this is due to variation in the precise bundling of features on functional heads and in the PF-parameters approach it is because the mapping from narrow syntax to the linear speech signal is underspecified and filled in in variable ways (as discussed below).

It is important to note that, while Chomsky himself has arguably become less interested in parameters (as Baker, this volume, also notes), parameters remain very much on the research agenda for many generative syntacticians. Unsurprisingly, this has led to further innovations in the parametric approach, notably the idea that parameters are arranged in hierarchies (see Baker 2001, Roberts 2012, 2019, Biberauer, Holmberg, Roberts, and Sheehan 2014, Sheehan 2014, van der Wal 2017) and the proposal, developed by Biberauer (2011, 2017) and Ramchand and Svenonius (2014), that

parameters are fully "emergent" because features/heads themselves are not specified as part of UG. Another much-discussed issue is the difference between macro- and micro-parameters (see Kayne 2005, Baker 2008 for discussion). Even these kinds of parameters, though very different from the concrete proposals in LGB, are, I would argue, in the same spirit. As Chomsky notes, after all, what is crucial is not that UG produces a finite set of grammars but rather that it reduces "the class of grammars compatible with primary linguistic data" (Chomsky 1981, 13). N. Richards (2016), building on earlier work, offers a new kind of parametric theory that, in a sense, turns the Berwick and Chomsky proposal on its head. In his approach, the syntax needs to build structures consistent with the morphophonological rules of a given languages, so prosodic requirements actually trigger syntactic movement, for example. In this sense, the requirements of externalization permeate the syntax, triggering syntactic operations. It seems to me that any explicit theory that attempts to model variation in the context of a theory of UG can be considered to share the same basic aims as the principles and parameters approach, despite these differences in detail. Given the amount of work left to do in this domain, it seems productive to continue to explore different kinds of analyses of cross-linguistic variation.

In the following section I consider two examples of cross-linguistic variation and sketch different parametric approaches in line with the three kinds of parameters introduced in this section, by way of illustration.

11.3 Word Order Variation

11.3.1 Head-Complement Orders

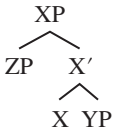
Word order is a very obvious point of variation across languages. English places the subject first in the (declarative) sentence, followed by the verb and then the object, but all of the six potential orders between subject verb and object have been claimed to be possible as the basic word orders of human languages (see Dryer 2013). Early work by Greenberg (1963) suggested, however, that while there is substantial variation, there are also nontrivial patterns regarding the dominant word orders of human languages. He noted, for example, that, in his sample of relatively diverse languages, the position of the verb is often correlated with the order of preposition/postposition and noun, with both VSO and SVO languages tending to have prepositions (preceding the noun phrase) and SOV languages (5a), postpositions (following the noun phrase) (5b):

(5) Head-final word order in Turkish

a.	Ahmet	kitab-*ı*	oku-du
	Ahmet	book-ACC	read-PAST
	"Ahmet read the book."		
b.	k*ı*z	amnesi	için
	girl	mother.3S	for
	"for the girl's mother"		

In early principles and parameters approaches, phrase structure was argued to be subject to a universal X-bar template of the following kind, which represented both hierarchical structure and linear order:

(6) The X-bar template



The variation identified by Greenberg equated, in the model in (6), to variation in the order of heads (X) and their complements (YP) with both verbs and prepositions/postpositions being heads (X). In early Principles and Parameters terms, then, this correlation could be stated in the following terms, as a parameter of X-bar theory (see Stowell 1981; Koopman 1984; Travis 1984):

(7) The GB head parameter: X precedes/follows its complement phrase.

In this kind of approach, linear order is specified in the syntax via the parameterized head-complement of X-bar theory.

Later work by Dryer (1992) established a broader typological tendency for word order harmony across additional pairings such as the following, with illustrative examples from English:

(8) Correlation pairs (Dryer 1992: Table 39, p. 108)

(i)	auxiliary verb-VP	have [eaten the cake]
(ii)	complementizer-S(entence)	that [he must leave]
(iii)	adverbial subordinator-S(entence)	because [he must leave]
(v)	article-noun	the [big red bus]
(vi)	verb-PP	depend [on someone]
(vii)	noun-relative clause	person [I once knew]
(viii)	verb-manner adverb	run [very slowly]
(ix)	verb-subject	(there) entered [a man]

In all such cases, these pairs of categories show a tendency to correlate with the order of verb and object in a given language. Many of these examples involve categories that are usually analyzed as structural X-YP pairings in Principles and Parameters approaches for independent reasons (this is true arguably of at least (i)–(vi)), though not necessarily for (vii–ix). Moreover, the pairs of categories that Dryer shows not to correlate with the order of verb and object are not usually taken to involve head-complement pairings, but rather to involve specifiers (ZP in (3)) and/or adjuncts (which are added to the X-bar template in a different way):

(9) Non-correlation pairs (Dryer 1992: Table 40, p. 108)

(i)	adjective-noun	old car
(ii)	demonstrative-noun	this car
(iii)	adverbial intensifier-adjective	very old
(iv)	verb-negative particle	do not

To some extent then, the head parameter meets the requirement of explaining both what is universal (structure) and what varies across languages (word order) in a simple and elegant way. Head-complement pairs in a given language show a tendency to

be ordered in the same way in a given language, whereas specifier/adjuncts behave differently.

The head parameter is not without its problems, however. First, pairings (vii)–(ix) in (8) are not so easily reducible to the head parameter as they involve categories that are not usually analyzed as involving head-complement pairs. Second, as Hawkins (1982) points out, the head parameter is empirically inadequate in that it does not allow for the fact that many languages are not fully head-initial or head-final across all head-complement pairs. Rather, as Hawkins and Dryer both note, most languages arguably display some degree of mixing of both head-initial and head-final structure, despite the general tendencies.

Already in the earliest discussions of the head parameter, it was, of course, noted that languages were not consistently head-initial or head-final. Approaches like that of Koopman (1984) and Travis (1984), in particular, proposed to derive mixed orders via movement. Kayne's (1994) Linear Correspondence Axiom (LCA) essentially extended this kind of approach in proposing that movement was necessary to derive *any* head-final word order. Actually, more accurately, Kayne proposed that we assume that the syntax has no linear order but that linear order is mapped transparently from syntactic structure so that material higher in a syntactic tree precedes material that is lower down. The advantage of this proposal is that there is a straightforward transparent mapping between syntactic structure and linear order, with syntax containing only hierarchical and not linear relations. The practical outcome of this proposal was that the number and nature of movements postulated to exist in natural languages was vastly increased. In languages like Japanese, Turkish, and Korean, which are pretty consistently head-final, movement was required so that all complements (YPs) move to a position higher than (c-commanding) their selecting head (X) in order to precede it. The evidence for such an approach comes from a number of striking word order asymmetries, some of which had also been discussed by Greenberg (e.g., the fact that subjects overwhelmingly tend to precede objects linearly). In a sense then, the LCA approach to word order instantiates the early Minimalist approach to parametric variation. In fact, on some LCA-based approaches, all "roll-up" movements are triggered by functional heads (see Cinque 2005), and so word order reduces to differences in the feature specifications of these functional heads (i.e., whether they trigger movement or not). The great disadvantage of the LCA is that unlike the proposals by Travis and Koopman, it forces many movements to take place which appear to be motivated only by the need to create a surface head-final order. This, in turn, creates challenges for many of the established restrictions on movement, such as the generalization that you cannot move something out of something that has already moved (freezing). By way of illustration, consider the following examples from English that show that it is possible to extract a wh-phrase from a subject only where the latter has not moved to the canonical subject position

(10) a. *Which celebrity were [pictures of t] all over town?
b. Which celebrity were there [pictures of t] all over town?

The problem for the LCA is that it implies that all complements are moved in head-final languages, predicting freezing across the board. In fact, head-final phrases seem to permit extraction more easily than head-initial phrases.

Despite the continuing influence of the LCA, one could take Berwick and Chomsky (2011) to be rejecting it in their move to PF parameters. Indeed, they explicitly cite

word order as being matter only for externalization.[7] If we give up the LCA in its strongest form, then it is possible to combine the attractive idea that the narrow syntax contains only hierarchical relations with the elegance and simplicity of the original GB head parameter. The head-complement relation, being symmetrical, rather than asymmetrical, is regulated at PF (M. Richards 2004, Abels and Neeleman 2009, 2012). In these terms, as Berwick and Chomsky suggest, the mapping from the narrow syntax to PF is more complex as it is parameterized, but the narrow syntax itself is more uniform as it lacks the additional movements needed to derive head-final word orders (and the problems they create). Although the LCA remains influential in generative grammar, it seems fair to say that the PF-parameter approach to word order is gaining in influence. The following two sections discuss further word order issues where both kinds of parametric analyses exist. [8]

11.3.2 Spec-Head Orders and Universal 20

There are other curious word order universals identified by Greenberg, notably his Universal 20, which concerns the order of constituents within the extended noun phrase:

(11) Greenberg's Universal 20 (U20)

> When any or all of the items (demonstrative, numeral, and descriptive adjective [*these two red* - MS]) precede the noun, they are always found in that order. If they follow, the order is either the same or its exact opposite. (Greenberg 1963, p. 87)

As Cinque (2005) notes, in his discussion of U20: "Of the 24 mathematically possible orders of the four elements demonstrative, numeral, adjective, and noun, only 14 appear to be attested in the languages of the world." From a principles and parameters perspective, word order asymmetries/gaps of this kind are highly intriguing as they may reveal something about universal grammar.[9] Cinque provides a UG-based account of U20, based on the assumption that all languages start off with the following order of Merge of these NP constituents:

(12) Base order of NP
Dem > Num > Adj > N
These > two > red > apples

What Cinque then shows is that it is possible to explain U20 if we assume the LCA so that all other orders are derived via movement and we adopt an independent requirement that all NP-internal movements must move a constituent containing the noun itself. Space precludes a full illustration here, but essentially, this condition correctly rules out all 10 unattested orders while ruling in all 14 attested patterns. At face value then, U20 appears to be potential evidence for the LCA and the early Minimalist view of word order, and against a PF-parameter approach to word order.

As Abels and Neeleman (2009, 2012) show, however, the LCA is not actually a crucial ingredient of Cinque's elegant explanation of U20. The asymmetry and gaps can also be explained if head-complement orders are regulated by a PF-head parameter so that many different word orders can be base generated. Nonexistent orders can still be ruled out as long as where movement does take place it is always to the left and Cinque's condition that all NP-internal movement must involve a constituent containing the noun is

maintained. Abels and Neeleman advocate rejecting the LCA, given these facts, and they also show that the LCA is actually less restrictive than it at first seems. In their words: "The LCA is toothless without a restrictive theory of movement, but [..] it can only be reconciled with the data in the absence of such a theory" (p. 25).

11.3.3 The Final-over-Final Condition

An apparent challenge for Abels and Neeleman's claim that the LCA is not involved in regulating the order between heads comes from the Final-over-Final Condition (FOFC), first observed by Holmberg (2000), and discussed at length by Biberauer, Holmberg, and Roberts (2014) and Sheehan et al. (2017). Stated in its most neutral terms, FOFC works as follows:

(13) The Final-over-Final Condition (FOFC)
A head-final phrase cannot immediately dominate a head-initial phrase if the heads of both phrases are part of the same relevant domain.

To give a concrete example, what (10) specifies is that whereas the structure [Aux [O(bject) V]] is possible (and attested), the structure [[V O] Aux] is problematic since here the topmost head Aux is head-final whereas the verb phrase is head-initial (see Biberauer, Holmberg, and Roberts 2014 for extensive evidence for this particular asymmetry).

The fact that such an asymmetry can be observed in the ordering between heads poses a potential challenge for a PF-parameter approach to word order, suggesting something akin to the LCA may still be required. Indeed, Biberauer, Holmberg and Roberts (2014) draw this very conclusion, proposing an account of FOFC whereby head-final orders are derived via movement coupled with the condition that the feature triggering complement-to-specifier movement must be present from the lowest head in a given domain (an extended projection), an account very similar in spirit to Cinque's analysis of U20. Once again, however, it is possible to state their analysis without the LCA. If head-finality is, in some sense, marked with respect to head-initiality, then all that is needed to explain FOFC is the stipulation that head-finality must begin at the bottom of an extended projection. Abels and Neeleman's critique of Cinque might equally be levelled at this analysis of FOFC, therefore. In a sense, though, the LCA does more work here in providing a rationale for the idea that head-finality is more marked than head-initiality.

There have been other accounts offered of FOFC, however, which either do not rely on the LCA or do so in a modified way. In my own work (see Sheehan 2013), I have claimed, for example, that FOFC can be explained via a revised version of the LCA whereby the latter is required to order head-complement pairs only in contexts of mixed head-initial/head-final orders. In basic terms, the idea is that a PF head parameter regulates the order between heads under selection, along the lines proposed by Richards (2004). As long as all heads are initial or final, this yields a total linear order between all heads transitively.

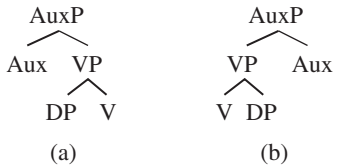
(14) a. V>O, Aux>V → Aux>V>O
b. O>V, V>Aux → O>V>Aux

However, in contexts of mixed orders, transitive head-head orders do not yield a total linear order.

(15) a. O>V, Aux>V → ?
b. V>O, V>Aux → ?

In (15a-b) no order is specified between Aux and O. In these contexts, asymmetric c-command is used to resolve this issue. Consider the trees, for (15a-b), where DP represents the object (O) :

(16)



In the licit initial-over-final order in (16a), Aux asymmetrically c-commands DP (O) and so, a total linear order is possible between the three constituents (17a). In (16b), however, the illicit final-over-initial order, Aux still asymmetrically c-commands the object DP and so must precede it. This does give a total ordering, but not the expected one. Rather, we get the order in (17b), whereby Aux surfaces between V and O. Crucially, there is no way to derive the FOFC-violating linear order V>O>Aux from the structure in (16b):

(17) a. O>V, Aux>V + Aux>O → Aux>O>V
b. V>O, V>Aux + Aux>O → V>Aux>O

The V>Aux>O order is attested, though infrequently (see Sheehan 2013), unlike the V>O>Aux order.

Though there is no general agreement regarding the correct account of word order variation, this is a fruitful area of study. Whatever the ultimate fate of the LCA, for example, it has led to a remarkable set of discoveries, including work in the cartographic approach which has revealed a seemingly universal functional sequence (see Cinque 2017 for a recent overview). While we are still a way away from understanding how best to describe these discoveries in terms of principles and parameters, it is unlikely that we would have discovered them at all, had we not tried.

11.4 Argument Expression

In many ways, it is not surprising that word order might be a PF parameter, given that it is arguably a fact about externalization. The status of other kinds of variation remains much more controversial, and the consensus certainly appears to go in favor of analyses stated in terms of the featural make-up of functional heads rather than PF parameters. In this section, we shift focus to argument expression, something that has been on the parametric agenda from its inception, and consider a number of different kinds of parametric approaches to this phenomenon. As noted above, much of LGB revolves around the correct formulation of the null subject parameter stated in GB terms and Chomsky's

ultimate proposal relates it to the way that agreement affixes are lowered onto the verb. Minimalist formulations of the pro-drop parameter in line with the Borer conjecture have arguably been successful in providing an explanatory account of the cluster of properties discussed in LGB, though some open issues remain.

Probably the most influential Minimalist account of the pro-drop parameter is that proposed by Alexiadou and Anagnostopoulou (1998) (see also Barbosa 1995 for a similar idea). They propose a highly intuitive account whereby what distinguishes pro-drop languages like Italian and Greek from non-pro-drop languages like English is the fact that the verbal agreement morphology can satisfy the subject requirement in the former languages. In simple terms, the idea is that rich morphology on verbal forms like *cant-amos* sing-1PL functions like an expletive pronoun, meaning that: (i) expletive subjects are not required; (ii) the subject can remain in a low, post-verbal position; and so (iii) the subject can be extracted from this low position, avoiding the "*that*-trace" filter. The *that*-trace filter refers to an effect first observed in English, but since observed in many other languages such as French, Nupe, and Yoruba, whereby there is a restriction on questioning/relativising preverbal subjects (see also the Italian data in (2)):

(18) a. I saw someone that I think (*that) t knows you.
b. Who do you think (*that) t should win?

It has long been noted that pro-drop languages lack this effect. The contrast between French, which has it, and Spanish/Italian/Portuguese, which lack it, is revealing in this respect, as, of these closely related languages, only French is not pro-drop. As in earlier approaches, this is attributed to the fact that the subject can remain post-verbal in pro-drop languages, avoiding the *that*-trace problem (however it is analyzed). One of the attractions of the Alexiadou and Anagnostopoulou (1998) proposal is that it explains the fact that, in many languages, subjects can be null but objects cannot. At least in Italian, Greek, and Spanish, this follows because the verb shows subject agreement but not object agreement (assuming that clitics are not agreement morphemes). As has oft been noted, the Alexiadou and Anagnostopoulou (1998) approach to null subjects is clearly consistent with the Borer conjecture, as what is at stake is the [+pronominal] status of AGR (a functional head) in these languages.

Even from the earliest work on the topic, however, there was an awareness that there were finer-grained distinctions to be made than a single parameter implies. Rizzi's initial version of the pro-drop parameter, for example is actually two parameters:

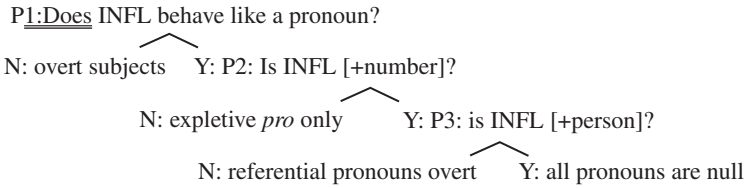
(19) Rizzi's (1982) null subject parameter(s)
(a) INFL can be specified [+pronoun]
(b) INFL can be referential.

[+pron, $F_i \ldots F_n$] (Rizzi 1982, 143)

So, what is at stake is not only where inflectional morphology functions as a pronoun (being [+pronoun]) but also whether it is referential. In Rizzi's words, "[w]hat has been considered so far to be as a single parameter of UG is to be decomposed into two subparameters [(a)-(b)] which are autonomous but related by an obvious intrinsic relation: we may assume that that specific grammars freely assign values 'yes' or 'no' to property [(a)]; if the value is 'yes,' then a value is assigned to property [(b)];

otherwise, the configuration referred to in [(b)] simply does not arise" (Rizzi 1982: 144). Rizzi (1986) further revises (4) so as to capture a further distinction: the availability of quasi-argumental vs. expletive *pro* (plus other differences in the licensing of null objects). His 1986 proposal can be characterized as a parameter hierarchy of the following kind:

(20)



The idea that parameters are more generally arranged in dependent hierarchies of this kind is developed in Roberts (2012, 2019), Sheehan (2014), Biberauer (2017), van der Wal (2017) as noted above. What this work shows is that, however parameters are stated, they often display dependency relations with other parameters. It seems potentially possible to modify Alexiadou and Anagnostopoulou's (1998) analysis to accommodate these different kinds of systems, but this is no trivial task and one that I will not attempt here.

There have also been PF-parameter approaches to the pro-drop parameter. Some such proposals are similar in spirit and predictions to Alexiadou and Anagnostopoulou's approach in that a D feature associated with rich agreement triggers deletion of a subject at PF (Sheehan 2006, Roberts 2010).[10] This approach makes different predictions about the status of preverbal subjects in pro-drop langauges, allowing for the fact that they may share properties with preverbal subjects in non-pro-drop languages. A different deletion approach is developed by Neeleman and Szendrői (2007, 2008). They point out that many languages which lack agreement morphology also permit null subjects, for example, Mandarin and Japanese. These radical pro-drop languages differ, however, from Italian and Greek in that they permit the omission not only of subjects but of any NP argument. Neeleman and Szendrői propose that radical pro-drop is due to a spell-out rule that spells out non-fusional pronouns as null. Fusional morphology is where a single element realizes more than one feature. For example, pronouns in English are fusional rather than agglutinative as they cannot be divided into a stem and case suffixes (I/me/my, he/him/his). In Japanese, on the other hand, case morphology is clearly agglutinating: kare-ga (he), kare-o (him). According to Neeleman and Szendrői's proposal, the null spell-out rule is available only in Japanese-style languages because of an elsewhere condition that essentially favors rules spelling out larger chunks of structure. Where there are separate rules for the subparts of inflected pronouns, the null spell-out rule will always be available and so favored, hence the possibility of null subjects. Where pronouns inflect, the rule spelling out full pronominal form blocks the null spell-out rule.

Once again, then, there are different ways of modeling variation in the availability of pro-drop with general agreement that there is not, in fact, a single pro-drop parameter. Once again, investigations into the availability and use of null subjects have nonetheless been highly fruitful empirically, leading to many intricate discoveries, not least those discussed by Rizzi (1979, 1982, 1986).

Even successful theories like that of Alexiadou and Anagnostopoulou face empirical challenges, but this highlights one of the great strengths of the parametric approach: explicit theories make falsifiable predictions. Just as Chomsky was able to rule out certain versions of the pro-drop parameter stated in terms of government on an empirical basis, it is also possible to test specific parametric theories empirically and then adjust them or reject them in the light of new data. From an outsider's perspective, it may appear like the ground is always shifting and every proposal turns out to be wrong, but this continual development, which has always been advocated by Chomsky himself, is actually a healthy sign. Sometimes, critics of the parametric approach claim that no progress has in fact been made via this approach. It is true that there are multiple different ways to state the pro-drop parameter and the head parameter with no clear consensus as to which is the "correct" version, probably because no existing proposal is completely correct. It is also true, however, that in exploring these different versions of parameters many intricate empirical discoveries have been made about languages and many kinds of analyses have been ruled out. To this extent, then, the approach has been highly fruitful.

11.5 Conclusions and Outlook

As Baker (this volume) points out, one of the major legacies of Chomsky's work is to have highlighted the level of complexity of the grammar of any human language. In this vein, Chomsky's early parametric work presents some puzzles that have led to fruitful research programmes: including pro-drop, but also non-finite "control," impersonal passives, small clauses, clitics and clitic-doubling. In all cases, subsequent research, ever increasing in its depth and breadth, has led to many new empirical generalizations and contrasts to be explained. This in turn has led to changes to previously posited models, sometimes of quite a drastic kind. Rather than undermining the generative approach, however, this impressively complex variation would seem to be strong evidence for it. Whether one espouses the idea of innate universal grammar or not, what generative grammar has done, and continues to do, under Chomsky's influence, is to describe linguistic phenomena in more detail than ever before. Some might say that the very existence of this complex variation severely undermines the very concept of UG, but others would retort that models without UG still need to be sufficiently complex to model these grammatical phenomena and this does not necessarily get easier without parameters, but arguably harder. Regrettably, what has often happened is that some researchers outside of generative grammar reject the very complexities that have been discovered, preferring simpler models of grammar that model different things. This misleading simplification needs to be resisted. For while there are some phenomena of human language for which compelling nonparametric, often functionalist, analyses have been developed, there are many others for which no alternative explanation has been offered at all, or for which competing analyses fail to model large swathes of data. Chomsky's move to Minimalism holds great promise for the unification of different approaches to language in that it explicitly states that non-UG-specific explanations are to be favored over UG-based explanations. There are some findings about human languages, however, that have been resistant to non UG-specific explanations so far (e.g., Cinque 2017), and they remain a challenge for the strongest Minimalist view as well as for nongenerative approaches.

Endnotes

1 Given the brevity of this chapter, I will only touch briefly on some of the objections which have been raised to parametric approaches to variation. For further discussion of these issues see Biberauer (2008), Boeckx (2014), Roberts (2019) and the exchanges between Newmeyer (2005, 2006) and Roberts and Holmberg (2005).

2 Though Chomsky is equivocal on this point, noting that it may be possible to formulate an adequate theory of UG based on "an idealization that would permit an infinite class of grammars" (Chomsky 1981, 13), the approach he takes is not of that kind. We return to this issue below in relation to the post-Minimalist era in which this idea is often given up.

3 See Baker (2001) for a very accessible introduction to the UG-specified notion of parameters.

4 This concept of parameters is often referred to as the "Borer-Chomsky conjecture" (indeed, I have referred to it in this way myself), but Chomsky himself has pointed out that the idea originates with Borer and not with him, so I adopt the more accurate label here.

5 The extent to which Minimalist approaches address the poverty of the stimulus issue depends on the specific assumptions made and these tend to be subtly different across approaches. In Westergaard's (2014) micro-cues approach, for example, "UG provides children with principles, features, and the ability to parse, but not the micro-cues themselves, which are considered to be part of the knowledge of a specific language" (p 26). This kind of model still addresses the poverty of the stimulus model but moves away from language acquisition as a process of narrowing down.

6 Boeckx (2014) bemoans the fact that the term *parameter* is often now used to mean merely "difference between languages" rather than a clustering of effects. This objection could potentially apply also to the label PF parameter. However, it is at least possible that there are more substantive PF parameters of the kind discussed below which lead to multiple surface effects.

7 One can interpret Berwick & Chomsky's claim in different ways of course. In one sense, the LCA also says that word order is a matter only for externalization, but in practice, the LCA forces PF-related movements to happen in the syntax, so it is not compatible with the idea that syntax is uniform across human languages, varying only at the point of externalization.

8 Terje Lohndal notes that it remains unclear what the criteria are for syntactic vs. PF movements. In relation to other word order effects, for example, such as subject auxiliary inversion and verb second, where movement appears to be involved, what would a PF analysis look like? One possibility would be that all languages are underlyingly verb second with subject auxiliary inversion but that spell-out targets different copies in different languages. Another possibility would be to simply relocate some kinds of movement in the PF component (see Erteschik-Shir 2005). Both kinds of analysis make predictions that would need to be tested.

9 Of course, there is always the risk that such asymmetries/gaps are simply the result of historical accidents. Chomsky himself notes that "[e]xisting languages are a small and in part accidental sample of possible human languages[.]" (Chomsky 1981, 1). In the case of U20, however, evidence from artificial language experiments suggest that this is not the case, and that there is a genuine cognitive bias at play here (Culbertson, Smolensky, and Legendre 2012).

10 A reviewer asks me how this is different from the idea that rich agreement in Italian-style languages has the ability to fully fulfil the subject function. The difference relates to the status of non-pronominal subjects. If the inflectional morphology fulfils the subject function, then there can be no true DP subjects. The same is not true in a deletion approach as long as something prevents deletion of full DP subjects but not pronouns.

References

Abels, K., and Neeleman, A. 2009. Universal 20 without the LCA. In *Merging Features: Computation, Interpretation, And Acquisition* edited by J. M. Brucart, A. Gavarró, J. Solà, 60-79. Oxford: Oxford University Press.

Abels, Klaus and Neeleman, Ad. 2012. Linear asymmetries and the LCA. *Syntax* 15 (1): 25-74. https://doi.org/10.1111/j.1467-9612.2011.00163.x

Alexiadou, A., and Anagnostopoulou, E. 1998. Parametrizing Agr: Word order, V-movement and EPP-checking. *NLLT* 16 (3): 491–539. https://doi.org/10.1023/A:1006090432389

Baker, M. 2001. *The Atoms of Language*. New York: Basic Books.

Baker, M. 2008. The microparameter in a microparametric world. In *The Limits Of Syntactic Variation*, edited by T. Biberauer, 351–374. Amsterdam: John Benjamins.

Barbosa, P. 1995. Null Subjects. PhD dissertation: MIT.

Berwick, R., and Chomsky, N. 2011. The biolinguistic program: The current state of its development. In *The Biolinguistic Enterprise*, edited by A-M. Di Sciullo & C. Boeckx, 19–41. Oxford: OUP.

Biberauer, T (ed). 2008. The limits of syntactic variation. Amsterdam: John Benjamins.

Biberauer, T. 2017. Factors 2 and 3: A principled approach. *Cambridge Occasional Papers in Linguistics* 10: 38-65. https://doi.org/10.5565/rev/catjl.219

Biberauer, T., Holmberg, A., and Roberts, I. 2014a. A syntactic universal and its consequences. *Linguistic Inquiry* 45 (2):169–225. https://doi.org/10.1162/LING_a_00153

Biberauer, T., Holmberg, A., Roberts, I, and Sheehan, M. 2014b. Complexity in comparative syntax: The view from Modern Parametric Theory. In *Measuring Grammatical Complexity*, edited by F. Newmeyer and L. Preston, 103–127. Oxford: OUP.

Boeckx, C. 2014. What Principles and Parameters got wrong. In *Linguistic Variation in the Minimalist Framework*, edited by C. Picallo, 155–178. Oxford: OUP.

Borer, H. 1984. *Parametric Syntax*. Dordrecht: Foris.

Chomsky, N. 1981. *Lectures on Government and Binding*. Dordrecht: Foris.

Chomsky, N. 1995. *The Minimalist Program*. Cambridge: MIT Press.

Cinque, G. 2005. Deriving Greenberg's Universal 20 and its exceptions. *Linguistic Inquiry* 36, 315–332. https://doi.org/10.1162/0024389054396917

Cinque, G. 2017. On the status of functional categories (heads and phrases). *Language and Linguistics* 18 (4):521-576 DOI:10.1075/lali.18.4.01cin

Culbertson J, Smolensky P., and Legendre G. 2012. Learning biases predict a word order universal. *Cognition* 122 (3):306–329. doi: 10.1016/j.cognition.2011.10.017.

Dryer, M. S. 1992. The Greenbergian word order correlations. *Language* 68: 81–138. DOI: 10.2307/416370

Dryer, M. S. 2013. Order of subject, object and verb. In The World Atlas of Language Structures Online, edited by M. S. Dryer and M. Haspelmath. Leipzig: Max Planck Institute for Evolutionary Anthropology. (Available online at http://wals.info/chapter/81, Accessed on 2019-10-11.)

Erteschik-Shir, N. 2005. Sound patterns of syntax: Object shift. *Theoretical Linguistics* 31. 47–93. https://doi.org/10.1515/thli.2005.31.1-2.47

Fukui, N. 1986. *A Theory of Category Projection and Its Applications*. PhD dissertation: MIT.

Fukui, N. 1988. Deriving the differences between English and Japanese: A case study in parametric syntax. *English Linguistics* 5: 249–270. https://doi.org/10.9793/elsj1984.5.249

Greenberg, J. H. 1963. Some universals of grammar with particular reference to the order of meaningful elements. In *Universals of Language,* edited by J. Greenberg, 73–133. Cambridge, MA: MIT Press.

Hauser, M. D., Chomsky, N., and Fitch, W. T. 2002. The faculty of language: What is it, who has it, and how did it evolve? *Science* 298: 1569–79. DOI: 10.1126/science.298.5598.1569

Hawkins, J. 1982. Cross-category harmony, X-bar and the predictions of markedness. *Journal of Linguistics* 18 (1):1–35. https://doi.org/10.1017/S0022226700007210

Holmberg, A. 2000. Deriving OV order in Finnish. In *The Derivation of OV and VO*, edited by P. Svenonius, 123–152. Amsterdam: John Benjamins.

Kayne, R. S. 1994. *The Antisymmetry of Syntax*. Cambridge: MIT Press.

Kayne, R. S. 2005. *Movement and Silence*. Oxford: OUP.

Koopman, H. 1984. *The Syntax of Verbs: from Verb Movement Rules in the Kru Languages to Universal Grammar*. Dordrecht: Foris.

Neeleman, A., and Szendrői, K. 2007. Radical pro drop and the morphology of pronouns. *Linguistic Inquiry* 38 (4):671–714. https://doi.org/10.1162/ling.2007.38.4.671

Neeleman, A., and Szendrői, K. 2008. Case morphology and radical pro-drop. In *The Limits of Syntactic Variation*, edited by T. Biberauer, 331–350. Amsterdam: John Benjamins.

Newmeyer, F. J. 2005. *Possible and Probable Languages: A Generative Perspective on Linguistic Typology*. Oxford: OUP.

Newmeyer, F. J. 2006. *A rejoinder to On the role of parameters in Universal Grammar: A reply to Newmeyer by Ian Roberts and Anders Holmberg*. Unpublished manuscript, University of Washington, Seattle.

Ramchand, G. and Svenonius, P. 2014. Deriving the functional hierarchy. *Language Sciences* 46:152–174. https://doi.org/10.1016/j.langsci.2014.06.013

Richards, M. 2004. *Object Shift and Scrambling in North and West Germanic: A Case Study in Symmetrical Syntax*. PhD dissertation, University of Cambridge.

Richards, N. 2016. *Contiguity Theory*. Cambridge: MIT Press.

Rizzi, L. 1979. *Remarks on variables, negation and wh-movement*. Unpublished manuscript, Scuola Normale Superiore.

Rizzi, L. 1982. *Italian Syntax* . Dordrecht: Foris.

Rizzi, L. 1986. Null objects in Italian and the theory of 'pro'. *Linguistic Inquiry* 17 (3): 501–558. https://www.jstor.org/stable/4178501

Rizzi, L, and Shlonsky, U. 2007. Strategies of subject extraction. In *Interfaces + Recursion = Language? Chomsky's Minimalism and the View from Semantics*, edited by U. Sauerland, and H.-M. Gartner, 115–160. Mouton de Gruyter.

Roberts, I., and Holmberg, A. 2005. On the Role of Parameters in Universal Grammar: A Reply to Newmeyer. In *Organizing Grammar: Linguistic Studies in Honor of Henk van Riemsdijk*, edited by H. Broekhuis, N. Corver, R. Huybregts, U. Kleinhenz, and J. Koster, 538–553. Berlin: Mouton/de Gruyter.

Roberts, I. 2010. A deletion analysis of null subjects. In *Parametric Variation, by T. Biberauer, A. Holmberg, I. Roberts, and M. Sheehan*, 58–87. Cambridge: CUP.

Roberts, I. 2012. Macroparameters and minimalism: A programme for comparative research. In *Parameter Theory and Linguistic Change*, edited by C. Galves, S. Cyrino, R. Lopes, F. Sândalo and J. Avelar, 320–335. Oxford: Oxford University Press.

Roberts, I. 2019. *Parameter Hierarchies and Universal Grammar*. Oxford: OUP.

Smith, N., and Law, A. 2009. On parametric (and non-parametric) variation. *Biolinguistics* 3:332–343.

Sheehan, M. 2006. The EPP and Null Subjects in Romance. PhD dissertation, Newcastle University.

Sheehan, M. 2013. Some implications of a copy theory of labeling. *Syntax* 16 (4): 362–396. https://doi.org/10.1111/synt.12010

Sheehan, M. 2014. Towards a parameter hierarchy for alignment. In Proceedings of WCCFL 31, edited by R. E. Santana-LaBarge, 399–408. Somerville, MA.: Cascadilla Press.

Sheehan, M, Biberauer, T, Roberts, I., and Holmberg, A. 2017. *The Final-over-Final Condition*. Cambridge: MIT Press.

Stowell, T. 1981. *Origins of Phrase Structure*. PhD dissertation: MIT.

Travis, L. 1984. *Parameters and Effects of Word Order Variation*. PhD dissertation: MIT.

van der Wal, J. 2017. Flexibility in symmetry: An implicational relation in Bantu double object constructions. In *Order and Structure in Syntax II: Subjecthood and Argument Structure*, edited by M. Sheehan and L. R. Bailey, 115–152. Berlin: Language Science Press.

Westergaard, M. 2014. Linguistic variation and micro-cues in first language acquisition. *Linguistic Variation* 14 (1): 26–45. https://doi.org/10.1075/lv.14.1.02wes

12

Constraints on Grammatical Dependencies

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12.1 Overview

Noam Chomsky is responsible for creating the field of research on grammatical theory in its present form, and he has also been material in providing frameworks for syntactic analysis, from early transformational grammar (see Chomsky (1957; 1975)) to current implementations of the minimalist program (see Chomsky (2001; 2008; 2013), Chomsky et al. (2019)). Against the background of these (and other) syntactic frameworks, a huge number of constraints on grammatical dependencies have been proposed over the years, most of them by other scholars, but quite a few of them also by Chomsky himself. Some of these constraints have become famous both within and outside of the field of linguistics, like the Subjacency Condition (Chomsky (1977)), the Empty Category Principle (ECP; Chomsky (1981)), and Principles A, B, and C of the theory of binding (Chomsky (1981)). Other constraints initially suggested by Chomsky have a more troubled history, in the sense that they have variously been claimed to be empirically falsified, considered conceptually flawed, or simply consigned to oblivion. One goal of this chapter is to argue that some of the constraints arguably belonging to this latter group can, upon closer scrutiny, in fact be shown to be at the heart of current syntactic theory, and qualify as "good" (in a sense to be made precise), whereas this does not necessarily hold for constraints in the former group. More specifically, based exclusively on a consideration of constructions involving displacement (movement) of syntactic categories, I will show that the A-over-A Principle (Chomsky (1964a)), the Superiority Condition (Chomsky (1973)), the Phase Impenetrability Condition (PIC; Chomsky (2001)) and the Strict Cycle Condition (SCC; Chomsky (1973; 1995)) together form the core of a comprehensive, beautiful theory of (relativized and rigid) locality, whereas constraints like the ECP have no place in current syntactic models.

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12.2 Constraints

Sentences in natural languages have a hierarchical structure. This structure can be generated (or licensed) in various ways, by a structure-building component of grammar. One specific proposal that has been widely adopted in recent years is that syntactic structures are generated incrementally, from bottom to top, by a recursive operation of Merge (Chomsky (2001), Hauser et al. (2002)). Merge can create basic structures like (1-a) by first combining the verb (V) with the object noun phrase (DP), which results in a VP, next combining an abstract functional head v (encoding agentivity) with the VP, which results in a v′ projection, and then combining v′ with the subject (DP), which results in a vP projection. In (1-a), all Merge operations are *external* since none of the two items that are put together is part of the other one before the operation applies. (1-b) and (1-c) show that structure-building can also involve *internal* Merge, where one of the two items was part of the other one before the operation takes place. In (1-b), a functional head T(ense) is (externally) merged with the complex vP in (1-a), yielding T′; and internal Merge applies afterwards to T′ and the subject DP, leaving a trace (or a copy) in the original position (the trace t is coindexed here with the displaced DP for reasons of perspicuity). Internal Merge accounts for a universal property of natural languages, viz., that they all involve *displacement* (or movement): Items may occur in places that are clearly not their base positions. This already suggests itself in (1-b) (where DP_1 is introduced locally by v, not by the T element *will*); and it is even clearer in (1-c), where a TP that minimally differs from the one in (1-b) (by merging $[_V$ *like*] with $[_{DP}$ *who(m)*] instead of $[_{DP}$ *him*]) is first externally merged with a C(omplementizer) head, and the resulting C′ is then combined with the DP object, via internal Merge, thus bringing about so-called wh-movement and yielding a clause (CP). (1-c) can then be merged with a CP-embedding verb, and given further Merge operations in the matrix clause, this may lead to a sentence like (1-d). Alternatively, however, internal Merge will also apply to the embedded DP_2 and a matrix C′, as in (1-e), which yields non-clause bound displacement.

(1) a. $[_{vP}$ $[_{DP}$ she] $[_{V'}$ v $[_{VP}$ $[_V$ kiss] $[_{DP}$ him]]]]
b. $[_{TP}$ $[_{DP_1}$ she] $[_{T'}$ $[_T$ will] $[_{vP}$ t_1 $[_{V'}$ v $[_{VP}$ $[_V$ kiss] $[_{DP}$ him]]]]]]
c. $[_{CP}$ $[_{DP_2}$ who(m)] $[_{C'}$ C $[_{TP}$ $[_{DP_1}$ she] $[_{T'}$ $[_T$ will] $[_{vP}$ t_1 $[_{V'}$ v $[_{VP}$ $[_V$ kiss] t_2]]]]]]]
d. I wonder $[_{CP}$ $[_{DP_2}$ who(m)] $[_{C'}$ C $[_{TP}$ $[_{DP_1}$ she] $[_{T'}$ $[_T$ will] $[_{vP}$ t_1 $[_{V'}$ v $[_{VP}$ $[_V$ kiss] t_2]]]]]]]
e. $[_{CP}$ $[_{DP_2}$ Who(m)] do you think $[_{CP}$ t_2 $[_{C'}$ C $[_{TP}$ $[_{DP_1}$ she] $[_{T'}$ $[_T$ will] $[_{vP}$ t_1 $[_{V'}$ v $[_{VP}$ $[_V$ kiss] t_2]]]]]]]]˜?

Clearly, there is no upper limit on the distance that an item like DP_2 in (1-e) can travel via internal Merge in a clause: Syntactic displacement is in principle unbounded; see, e.g., (2-a), with an additional CP separating *whom* from the position where it was externally merged (signaled by t_1). However, this is not yet the whole story. As was noted by Chomsky (1964a;b) early on, not everything is possible with displacement: There are restrictions that show that the structure-building component of syntax must be enriched by another component that contains syntactic constraints, so as to avoid overgeneration.[1] For instance, whereas (2-a) involves movement of an object across two complement clauses embedded by verbs, such movement becomes impossible if an intervening complement clause is embedded by a noun, as in (2-b) (where * signals ungrammaticality). Similarly, non-clause bound movement of subjects is much more

restricted than non-clause bound movement of objects; see, e.g., (2-c) vs. (2-d) (= a version of (1-e) where C is not empty but realized by *that*).

(2) a. Who(m)$_1$ do you think that Mary believes that she will kiss t$_1$?
b. *Which book$_1$ did John hear [$_{DP}$ a [$_{NP}$ [$_N$ rumour] [$_{CP}$ that you had read t$_1$]]] ?
c. *Who$_1$ do you think [$_{CP}$ that t$_1$ left] ?
d. Who(m)$_1$ do you think [$_{CP}$ that she will kiss t$_1$] ?

What data such as these show for movement can be generalized to all other grammatical dependencies relating two items in a sentence (like agreement, binding, case assignment, control, etc.): There must be constraints that restrict the power of pure structure-building in syntax. Given this state of affairs, the central question is what syntactic constraints look like.

Research over the last few decades has established a number of requirements that a syntactic constraint should meet in order to qualify as a plausible candidate for inclusion in the faculty of language. For the following discussion, I will adopt the criteria in (3).

(3) a. Constraints are as simple and general as possible.
b. Constraints are not complex.
c. Constraints do not require massive search space.
d. Constraints are principles of efficient computation or interface conditions.

First, (3-a) is really just a manifestation of an uncontroversial requirement for all scientific models: If there are two theories that account for the same set of data, the one is to be preferred that is superior with respect to simplicity, generality, and elegance. From this requirement, it follows that the number of Boolean operations in constraint definitions should be minimal (cf. Grimshaw (1998)). Furthermore, syntactic constraints should not mention specific information like, e.g., particular category (i.e., part of speech) features (or labels), or features characterizing arbitrary subclasses of the linguistic expressions that the constraint holds for. Evidently, construction-specific assumptions (let alone mentioning of individual lexical items) should be avoided in constraints. From this perspective, a constraint like the **that*-trace filter suggested in Chomsky and Lasnik (1977) to account for so-called complementizer-trace effects arising with movement of a subject *wh*-phrase from an embedded clause across a complementizer *that* to the matrix clause, as in (2-c), cannot be a good constraint.

Second, (3-b) presupposes that constraints on syntactic dependencies can be grouped into various classes determined by their complexity (see Müller and Sternefeld (2001), Graf (2013)). *Local derivational constraints* apply to individual syntactic operations (like Merge). *Local representational constraints* apply to syntactic output representations. *Global constraints* apply to whole derivations of sentences (i.e., successions of Merge and other operations); they correlate non-adjacent steps in the derivation (cf. Lakoff (1971); Chomsky's (1981) Projection Principle belongs in this class). *Transderivational constraints* are even more powerful since they require the construction of a reference set of competing syntactic derivations based on an initial input from which one derivation is picked out as optimal; this group includes the *Fewest Steps* condition selecting the derivation with the fewest number of operations that lead to convergence (Chomsky (2001)), the *Shortest Paths* condition selecting the derivation with the shortest movement paths (Chomsky (1995)), and the *Merge over Move* condition preferring a step of

basic structure-building (external Merge) to a movement step (internal Merge), in a given local domain (the phase); cf. Chomsky (2000), Frampton and Gutmann (1999), Hornstein (2009). Finally, there is a fifth type that can be referred to as *translocal constraints*. In contrast to transderivational constraints, a translocal constraint compares competing output representations, and picks one as optimal; a canonical constraint of this type is the *Avoid Pronoun* principle that favors representations with non-overt pronouns over representations with overt pronouns (Chomsky (1981), Haegeman (1995)). Given this taxonomy, a natural assumption is that only *local* constraints can be good constraints.

Third, (3-c) states that in order to determine whether a (local) constraint is violated, it should ideally not be necessary to check structures of potentially unbounded size; rather, the smaller the accessible window of a complex syntactic object is for evaluation, the better the constraint satisfies this requirement. This requirement is violated, e.g., by Fox and Pesetsky's (2005) *Cyclic Linearization* constraint that demands a preservation of linear precedence relations established in a low syntactic domain (a VP, or a clause) in all higher domains of a potentially complex sentence.

Fourth, the requirements in (3-d) have been at the core of minimalist research (see, e.g., Chomsky (2005)). Principles of efficient computation in the sense of (3-d) are basically local derivational economy constraints that can be motivated on grammar-external grounds. In contrast, interface conditions in the sense of (3-d) are representational constraints on outputs which are not motivated syntax-internally, but result from demands imposed on syntactic representations by the phonological and semantic interfaces – Phonological Form (PF) and Logical Form (LF), respectively. Thus, according to this far-reaching requirement, constraints that rely on concepts without independent motivation in terms of either economy or interface conditions are excluded.

Based on the requirements in (3), the next section will discuss Ross's island constraints and the ECP, concluding that none of these constraints qualifies as good (in the technical sense just laid out).

12.3 Constraints That Do Not Meet the Requirements

12.3.1 Island Conditions

Ross (1967) set out to develop a comprehensive system of so-called island constraints that severely restrict displacement operations in natural languages. However, it turns out that given the criteria in (3), none of the island constraints proposed in Ross (1967) (among them the *Complex NP Constraint*, the *Sentential Subject Constraint*, the *Coordinate Structure Constraint*, and the *Left Branch Condition*) qualifies as a good constraint. As a representative example, consider the Complex NP Constraint (CNPC) in (4), which blocks sentences like (5-a) (= (2-b)) in English (and many other languages), where wh-movement illegitimately takes place across both a CP ("sentence") and a DP ("noun phrase") with a lexical head (N), even though wh-movement from a complement CP is possible in principle (see (1-e), (2-a), (2-d)), as is wh-movement from an object DP (see (5-b)).

(4) *Complex NP Constraint* (CNPC):
No element contained in a sentence dominated by a noun phrase with a lexical head noun may be moved out of that noun phrase by a transformation.

(5) a. *Which book$_1$ did John hear [$_{DP}$ a [$_{NP}$ [$_N$ rumour] [$_{CP}$ that you had read t$_1$]]] ?
b. Who$_1$ did you read [$_{DP}$ a [$_{NP}$ [$_N$ book] [$_{PP}$ about t$_1$]]] ?

The CNPC is at variance with (3). For one thing, it is not maximally simple and general since it explicitly mentions category information (sentence:CP, noun phrase:DP, and lexical head noun:N) and thereby encodes a very specific construction. For another, the CNPC requires a massive search space spanning the whole structure in (5); in fact, it is a two-node constraint that requires keeping track of a node crossed earlier. And finally, it is hard to see how (4) could be viewed as a principle of efficient computation, or as an interface constraint. Essentially the same conclusions can be drawn for the other constraints on movement dependencies in Ross (1967); but also for similar types of constraints like Chomsky's (1964a) *Wh-Island Condition* (according to which movement must not take place from indirect questions) and Chomsky's (1973) *Tensed-S Condition* and *Specified Subject Condition*, all of which describe specific constructions and thus wear their violations of (3-a) (and also of (3-d)) on their sleeves. And it goes without saying that the same kinds of consequences arise for proposals like Zaenen and Pinkham's (1976) *Post-Sentential Subject Extraction Constraint* or Kuno's (1973) *Clause Non-final Incomplete Constituent Constraint*. As noted by Chomsky (1982, 74-76), Ross's island constraints and several other constraints of this general type have been immensely important for the development of the field, but only insofar as they provide a "taxonomy of properties" that makes it possible to "rethink conditions, to see whether one could deal with the […] phenomena […] in a unified way" (Chomsky (2002, 129-130)) and to "explain […] such constraints in terms of deeper and more natural principles from which their effects could be deduced" (Chomsky (1986b, 71-72)), and not as candidates for belonging to the faculty of language in their own right.[2]

12.3.2 The Empty Category Principle

The Empty Category Principle (ECP) was originally proposed in Chomsky (1981) (with refinements in Aoun, Hornstein, and Sportiche (1981), Chomsky (1986a), Lasnik and Saito (1984; 1992), and other work). It is, without any doubt, one of the most successful and widely discussed constraints on syntactic dependencies ever.[3] Unlike, say, the CNPC, it is not a derivational local constraint (blocking a syntactic operation), but a representational local constraint (that filters out certain structures resulting from the application of operations). More specifically, it is a constraint on *traces*, which was made possible by the introduction of the trace theory of movement in the previous decade (cf. Wasow (1972), Chomsky (1973, 266-269), Fiengo (1977)). As shown in (6), the ECP in its canonical formulation is extremely complex.

(6) *Empty Category Principle* (ECP):
Every trace t is marked [+γ].
A trace t is marked [+γ] iff it is properly governed.
A trace t is properly governed iff (a) or (b) holds.
a. t is antecedent-governed.
A trace β is antecedent-governed iff there is no barrier separating β from its immediate chain antecedent α (and if there is no wh-phrase or overt complementizer in the C domain that intervenes between α and β).

b. t is lexically governed.
A trace β is lexically governed iff it is in the m-command domain of a lexical category α, and no barrier separates β from α.

The ECP applies to syntactic representations at the level of Logical Form (LF), after abstract operations like wh-movement of in-situ wh-phrases and deletion of *that* complementizers and of intermediate traces of arguments (subjects or objects) have applied. It demands that traces left by movement have to be marked [+γ]; a trace can be marked [+γ] only if it is properly governed; and it can be properly governed either via antecedent-government, or via lexical government. Given certain assumptions (in particular, the additional stipulation in brackets in (6-a), which is necessitated by the move from a single COMP position in Chomsky (1981) to a specifier head configuration SpecC-C in Chomsky (1986a)), the ECP can account for complementizer-trace effects with subject movement across a lexical complementizer as in (7-a) (= (2-c)), as opposed to displacement from a CP that does not have an overt complementizer; see (7-b). This kind of effect does not show up with object movement because object traces, unlike subject traces, are lexically governed; so they are always properly governed, hence marked [+γ], and can never violate the ECP.

(7) a. *Who$_1$ do you think [$_{CP}$ t$'_1$ [$_{C'}$ [$_C$ that] [$_{TP}$ t$_1$ left]]] ?
b. Who$_1$ do you think [$_{CP}$ t$'_1$ [$_{C'}$ [$_C$ –] [$_{TP}$ t$_1$ left]]] ?

The ECP in (6) also correctly predicts that the complementizer-trace effect disappears if the complementizer intervenes at a later stage of the derivation, and the original subject trace can be antecedent-governed by an intermediate trace, as in (8-a); this latter intermediate trace cannot be marked [+γ], but, not being a final member of a wh-movement chain, it can be deleted before the ECP is checked at LF. Similarly, assuming that adjunct (i.e., adverbial) traces can only be [γ]-marked at LF (whereas argument traces are [γ]-marked as soon as they arise in the derivation), the non-occurrence of a complementizer-trace effect in (8-b) can be accounted for by postulating complementizer deletion before LF. (Still, in other environments where adjunct movement has to cross a barrier, such movement is correctly excluded.)

(8) a. Who$_1$ do you believe [$_{CP}$ that Mary thinks [$_{CP}$ t$'_1$ [$_{C'}$ [$_C$] [$_{TP}$ t$_1$ left]]]] ?
b. Why$_1$ do you think [$_{CP}$ t$'_1$ [$_{C'}$ [$_C$ that] [$_{TP}$ Mary left t$_1$]]] ?

The ECP also covers many so-called superiority effects, as in (9-b) vs. (9-a), assuming that there is LF *wh*-movement of the in-situ *wh*-phrase in multiple questions in English (which gives rise to a subject LF trace t$_1$ in (9-b) that is not properly governed, in contrast to the object LF trace t$_2$ in (9-a)).

(9) a. I wonder [$_{CP}$ who$_1$ t$_1$ bought what$_2$] → LF: [$_{CP}$ wh$_2$ wh$_1$ C t$_1$ … $\boxed{t_2}$]
b. *I wonder [$_{CP}$ what$_2$ who$_1$ bought t$_2$] → LF: [$_{CP}$ wh$_1$ wh$_2$ C $\boxed{t_1}$ … t$_2$]

In addition, subsequent research has identified many more ECP effects of diverse provenance, and in many different languages, exhibiting asymmetries between subject and object movement on the one hand, and between argument and adjunct movement on the other. However, despite its considerable empirical coverage, the ECP is not a

good constraint. First, as should be clear from (6), the ECP has a highly complex inner structure, involving a huge number of auxiliary concepts and a disjunction at its core (antecedent-government or lexical government); so it certainly does not look simple and general. This conclusion is reinforced by the fact that the constraint talks about a specific type of empty category (traces left by movement), rather than empty categories in general (including the *pro* postulated as an empty subject for seemingly subject-less sentences like *Ha parlato* ("has spoken") in Italian, and the PRO postulated as an empty subject of infinitives in control structures like *She tries to win*). And second, the ECP cannot naturally be conceived of either as a principle contributing to efficient computation or a condition imposed by the LF interface (the fact that it is *formulated* as an LF constraint notwithstanding). A systematic account of ECP effects in terms of constraints that meet the requirements in (3) is still outstanding.[4]

12.4 Constraints That Meet the Requirements

In contrast to the constraints discussed in the previous section, there are two pairs of constraints introduced by Noam Chomsky that are at the very heart of current approaches to locality in syntactic dependencies: on the one hand, the A-over-A Principle and the Superiority Condition (relativized locality), and on the other hand, the Phase Impenetrability Condition and the Strict Cycle Condition (rigid locality). I address the two concepts in turn.

12.4.1 Relativized Locality Constraints

12.4.1.1 The A-over-A Principle

The A-over-A Principle is arguably the first substantial locality constraint on grammatical dependencies that has ever been proposed; see Chomsky (1964a;b); the formulation in (10) essentially follows Chomsky (1973, 235) (also cf. Ross (1967, 10), Gazdar (1982, 176–177), Riemsdijk and Williams (1986, 20) for slightly different formulations).

(10) *A-over-A Principle*:
If a transformation applies to a structure of the form $[_{\alpha} \ldots [_{A} \ldots [_{A} \ldots] \ldots] \ldots]$, where α is a cyclic node, then it must be so interpreted as to apply to the higher phrase of the type A.

The standard interpretation (and also the original one adopted in Chomsky (1964b)) is that "A" in (10) is a variable over category features, i.e., labels. The constraint then states that movement of some category γ to some landing site Δ (in fact, any grammatical dependency involving γ and Δ) is impossible if there is another category β with the same category feature that dominates γ (in this case, β is *closer* to Δ than γ because the path from β to Δ is necessarily shorter than the path from γ to Δ). The A-over-A Principle is a local derivational constraint. It predicts that, within a given cyclic domain, a DP cannot be extracted from another DP; a VP cannot be extracted from a higher VP, and so on.[5] As such, the constraint makes a number of non-trivial correct predictions; however, as pointed out by Ross (1967), in the (label-based) interpretation standardly adopted, the A-over-A Principle leads to both undergeneration and overgeneration. The second

problem may make the A-over-A Principle look less plausible but is not fatal (after all, the data that the A-over-A principle cannot exclude even though one might intuitively think that it should – like, e.g., cases of illicit AP extraction from DP, as in **How intelligent do you have a sister?* – can always be excluded by some other constraint(s) in the grammar). The first problem is potentially severe, though. Examples like (5-b) show that a DP can in principle be moved out of another DP. Examples like those in (11-ab) (from English and German, respectively) indicate that a VP can undergo topicalization across another VP, and that a CP can be topicalized over another CP that initially dominates it.

(11) a. [$_{VP_2}$ Give a book to Mary] I don't [$_{VP_1}$ think [$_{CP}$ that she will t_2]]

b. [$_{CP_2}$ Dass er nett ist] hat Fritz behauptet [$_{CP_1}$ dass
that he nice is has Fritz$_{nom}$ claimed that
Maria gesagt hat t_2]
Maria$_{nom}$ said has

The well-formedness of these kinds of examples strongly suggests that the A-over-A Principle cannot be maintained in the interpretation given to "A" so far, viz., as a category label. However, following Ross (1967), the vast majority of the field seems to have reached the much more drastic conclusion that the A-over-A Principle should be abandoned in toto. In line with this, most textbooks on syntactic theory do not even mention this constraint anymore. Where it shows up, it is typically characterized as having been falsified by Ross (see, e.g., Riemsdijk and Williams (1986)). Very few textbooks introduce the constraint from a more neutral point of view (see Freidin (1992) for one exception), and even fewer have something positive to say about it (but cf. Hornstein et al. (2005), who mention the A-over-A Principle in passing).[6]

However, the obvious alternative to abandoning the constraint is, of course, to revise the assumption that "A" in (10) stands for a category label. As a matter of fact, this is exactly what Chomsky (1973, 235) does: He points out that it is possible to assume that the A-over-A Principle in (10) "does not establish an absolute prohibition against transformations that extract a phrase of type A from a more inclusive phrase of type A. Rather, it states that if a transformational rule is nonspecific with respect to the configuration defined, it will be interpreted in such a way as to satisfy the condition." As Chomsky also notes, "Alternatively, one might interpret the A-over-A constraint as legislating against any rule that extracts a phrase of type A from a more inclusive phrase A," which is the standard understanding facing empirical counter-evidence. Importantly, Chomsky's (1973) actual conclusion already is that "the former interpretation […] is perhaps more natural," and that he "will adopt it tentatively here, for this and other conditions to be discussed." What is more, this version of the A-over-A Principle is also adopted by Bresnan (1976): The item that can be subjected to a given transformation should be as inclusive as possible, independently of category labels (whereas an even more inclusive item that cannot be subjected to the same transformation because it does not fit its structural description can be ignored, even if it shares the same category label). Thus, under the revised understanding of "A" in (10) as the feature that is involved in the operation, the A-over-A Principle predicts that a wh-phrase cannot be moved out of a wh-phrase (but can move out of a non-wh phrase), a topic-marked phrase cannot move out of another topic-marked phrase, and so on. Let us now adopt a more contemporary approach according to which all syntactic operations are driven by designated features

(cf. Chomsky (1995; 2001), Pesetsky and Torrego (2006), Urk (2015), Collins and Stabler (2016) and Georgi (2017), among many others):[7] There are structure-building features (rendered here as [•F•]) that trigger movement and basic structure-building (internal and external Merge), and there are probe features (rendered as [∗F∗]) that trigger Agree operations as they underlie grammatical dependencies like case assignment, agreement, binding, and control (cf. Assmann et al. (2015) and references cited there for the notation). As far as movement is concerned, the A-over-A Principle can then be given the reformulation in (12), which is completely faithful to the reinterpretation of (10) along the lines of Chomsky (1973) and Bresnan (1976).

(12) *A-over-A Principle* (updated version):
In a structure $\alpha_{[\bullet F\bullet]}$ … [… $\beta_{[F]}$ … $\gamma_{[F]}$ …] …, γ cannot move to [•F•] if β dominates γ.

Incidentally, this version of the A-over-A Principle corresponds to a relativized locality constraint that has widely been proposed in the more recent literature (cf. Koizumi (1995), Fukui (1997), Kitahara (1997), Müller (1998), Sauerland (1999), Fitzpatrick (2002), Vicente (2007), Heck (2008), and Pesetsky (2013)), typically without reference to either Chomsky (1973) or Bresnan (1976). (12) provides a straightforward explanation for an otherwise mysterious restriction on the movement of remnant categories (i.e. categories from which extraction has taken place): Remnant movement of a certain type is impossible if the movement operation that has created the remnant is of the same type (cf. Takano (1994), Müller (2014)). This presupposes that different kinds of movement can be distinguished. For present purposes, we can confine attention to *scrambling* (see Ross (1967)), which is a movement type creating word order variation in free word order languages by moving a DP to a specifier of v (Specv); *wh-movement*, which moves a wh-phrase to a specifier of C (SpecC; see (1-c)); and *topicalization*, which is movement of a non-wh-phrase to SpecC. Given this assumption, the effect that the A-over-A Principle in (12) has on remnant movement is shown in (13-a) for DP scrambling from VP co-occurring with remnant VP scrambling in German (where VP topicalization would be perfect in the same context), in (13-b) for DP scrambling from CP co-occurring with remnant CP scrambling in Japanese, and in (13-c) for wh-movement from a wh-phrase co-occurring with remnant *wh*-movement of that latter, more inclusive wh-phrase in English.

(13) a. *dass [$_{VP_2}$ t_1 zu lesen] [$_{DP_1}$ das Buch] keiner t_2 versucht hat
that to read the book$_{acc}$ no-one tried has

b. *[$_{CP_2}$ Mary-ga t_1 yonda-to] [$_{CP_1}$ sono hon-o] John-ga t_2
Mary$_{nom}$ read-COMP that book$_{acc}$ John$_{nom}$

itta (koto)
said fact

c. *[$_{DP_2}$ Which picture of t_1] do you wonder [$_{CP}$ who$_1$ she likes t_2] ?

Given that scrambling and wh-movement involve different designated features on the attracting head and the moved item (like [•Σ•]/[Σ] for scrambling and [•wh•]/[wh] for wh-movement), the A-over-A Principle requires XP_2 to move first in (13-abc), so that

subsequent movement of XP_1 from the XP_2 in the derived position to a lower position will have to violate a number of other constraints (in particular, the Condition on Extraction Domain and the Strict Cycle Condition; see below).

Finally, note that this version of the A-over-A Principle meets all the requirements in (3). It is simple, general, and not complex. It is compatible with a larger search space, but it does not need it to be properly evaluated in any given derivation. And since it is essentially a minimality requirement that brings about a selection of the closest matching item, it can plausibly be viewed as a constraint contributing to efficient computation.

12.4.1.2 The Superiority Condition

The original formulation of the Superiority Condition is given in Chomsky (1973, 246).

(14) *Superiority Condition*:
No rule can involve, X, Y in the structure
… X … $[_{\alpha}$ … Z … -WYZ …] …
where the rule applies ambiguously to Z and Y and Z is superior to Y.

In current terms, a category is superior to another one if it asymmetrically c-commands it, i.e., if it shows up higher in the structure.[8] Furthermore, the condition that a rule applies ambiguously to two items captures exactly the same scenario that we have seen with the revised A-over-A Principle: Both items (Z and Y in (14)) can in principle be affected by the (movement) operation. (14) then demands that the higher, c-commanding one is to be affected by the transformation (or to be affected *first* if the transformation can apply more than once). Like the A-over-A Principle, the Superiority Condition can be given a fully faithful update, as in (15).

(15) *Superiority Condition* (updated version):
In a structure $\alpha_{[\bullet F \bullet]}$ … [… $\beta_{[F]}$ … $\gamma_{[F]}$ …] …, γ cannot move to [•F•] if β c-commands γ.

The Superiority Condition straightforwardly accounts for *wh*-movement asymmetries in multiple questions, as in (9) in English, without recourse to either the ECP or abstract LF movement: A subject *wh*-phrase c-commands an object wh-phrase and thus blocks its movement. Furthermore, unlike the ECP, the Superiority Condition accounts for similar intervention effects with two *wh*-objects, as in (16) (see Pesetsky (1982, 602ff)).

(16) a. $Whom_1$ did John persuade t_1 $[_{CP}$ to visit $whom_2$] ?
b. *$Whom_2$ did John persuade $whom_1$ $[_{CP}$ to visit t_2] ?

The constraint can also cover *wh*-island effects as in (17), where wh-movement of *how* illegitimately takes place from a wh-clause; thus, invoking a more specificic constraint like the Wh-Island Condition or the Subjacency Condition is not necessary to exclude these cases.

(17) *How_1 does $[_{TP_3}$ she know $[_{CP}$ $[_{DP_2}$ which car] $[_{TP_4}$ Mary fixed t_2 t_1]]] ?

In contrast, the Superiority Condition has nothing to say about topicalization from wh-islands, given that different movement-related features are involved ([top] vs. [wh]).

However, as noted by Fanselow (1987), the relevant examples are in fact well formed in German (unlike cases of wh-movement from wh-clauses); so this is a welcome consequence.

Like the A-over-A Principle, the Superiority Condition qualifies as a good constraint. First, it is simple and general. It is worth pointing out that, although it is usually treated as a constraint purely on wh-movement, there is nothing in the formulation of the Superiority Condition that would support the idea that it is confined to wh-environments.[9] Second, it is a local derivational constraint, and hence not complex. Third, it is compatible with, but does not presuppose, a large search space. And fourth, it implements a minimality requirement that lends itself to a classification as a principle of efficient computation.

Evidently, the A-over-A Principle in (12) and the Superiority Condition in (15) are two sides of the same coin; both constraints demand movement of the closest item, and the only difference is that closeness is defined in terms of domination in the first case, and in terms of c-command in the second. It thus makes sense to subsume the two constraints under a single, generalized Minimal Link Condition (MLC; see Chomsky (1995; 2001; 2008), and Takano (1994), Kitahara (1997), Müller (1998), Fitzpatrick (2002), Rackowski and Richards (2005), and Medeiros (2008), among many others).

12.4.2 Rigid Locality Constraints

The two constraints discussed in the previous section are relativized locality constraints since movement options for some item γ are not restricted to a fixed domain; rather, they are determined by the presence or absence of an intervening item β that is closer to the landing site. In contrast, *rigid* locality constraints on syntactic dependencies identify intrinsic, invariant properties of domains that make them (in-) accessible for syntactic operations.

12.4.2.1 The Strict Cycle Condition

The Strict Cycle Condition in (18) has been proposed for syntactic dependencies in Chomsky (1973, 243).

(18) *Strict Cycle Condition* (SCC):
No rule can apply to a domain dominated by a cyclic node *A* in such a way as to affect solely a proper subdomain of *A* dominated by a node *B* which is also a cyclic node.

The Strict Cycle Condition is arguably the single most important constraint in every derivational theory of grammar; see Chomsky (1995; 2001; 2004; 2008; 2019), Jacobson and Neubauer (1974), Perlmutter and Soames (1979)) Pullum (1992; 1979), Collins (1997), Kitahara (1997), Bošković and Lasnik (1999), Freidin (1999), Müller (2011), Abels (2012), Collins and Stabler (2016), and Gallego (2020), among many others, for discussion and alternative formulations.[10] This constraint ensures that once the derivation has created a certain structure, it is impossible to exclusively modify an embedded part of this structure. The degree of strictness of the constraint depends on how "cyclic node" is defined. According to the most restrictive concept, every projection is a cyclic node (also cf. footnote 5). On this view, every legitimate operation must involve the current root. Among many other things, the Strict Cycle

Condition is indispensable in a derivational account of freezing effects (Wexler and Culicover (1980), Browning (1991), Lohndal (2010)), as in (19-a) (with DP raising to subject in the passive interacting with wh-movement from DP in English) and (19-b) (with VP topicalization interacting with wh-movement from VP in German).

(19) a. *Who$_1$ was [$_{DP_2}$ a picture of t$_1$] painted t$_2$ by Mary ?
b. *Was$_1$ denkst du [$_{CP}$ [$_{VP_2}$ t$_1$ gelesen] hat keiner t$_2$] ?
what$_{acc}$ think you read has no-one$_{acc}$

Given that extraction from XP is possible only if XP is a complement (cf. the *Condition on Extraction Domain*; see Huang (1982), Chomsky (1986a), Cinque (1990)), the illformedness of (19-ab) can be derived if movement of DP$_2$ and VP$_2$ precedes extraction of DP$_1$ (because DP$_2$/VP$_2$ occupies a specifier when DP$_1$ extraction takes place); but the reverse, counter-cyclic sequence of movement operations where DP$_1$ extraction takes place when DP$_2$/VP$_2$ is still in situ, in a complement position, must also be excluded, and this is accomplished by the Strict Cycle Condition. Similarly, if it is assumed that the embedded *wh*-phrase in SpecC is responsible for the wh-island effect in a sentence like (17), the Strict Cycle Condition is needed to ensure that it is already present when movement of the other wh-phrase to the matrix domain takes place.

More generally, as observed by McCawley (1984; 1998), the Strict Cycle Condition predicts *orders* among syntactic operations. Given a very narrow concept of cyclic domains (the minimal projection), the constraint can thus resolve what would otherwise be indeterminacies in rule application. As a case in point, consider the dual role of (transitive) v heads. Under standard assumptions, v introduces an agentive (external) argument (i.e. it has a structure-building feature [•D•] triggering Merge of a DP with v′), and it can assign accusative case as an instance of Agree (i.e., there is a valued probe feature [∗acc∗] in addition). It is a priori unclear which operation has to take place first (with radically different consequences potentially arising; see Müller (2004)); but the Strict Cycle Condition working on minimal cyclic domains resolves the order in favor of Agree preceding Merge: Agree operates under c-command (cf. footnote 8); thus, Agree of v and an object DP in the VP affects solely the v′ domain. Hence, if such v′-based Agree were to take place after structure-building via Merge of the subject DP, i.e., in the presence of a higher cyclic domain vP, the Strict Cycle Condition would be violated; therefore Agree must precede Merge.

Sometimes a weaker version of the Strict Cycle Condition is adopted. For instance, Safir (2019, 292) proposes a *Peak Novelty Condition* that permits operations that are not *massively* counter-cyclic (i.e., reasonably close to the current root domain). Now and then, the concept of *Featural Cyclicity* has been pursued (cf. Richards (2001) and Preminger (2018), among others); here the only requirement is that active features that can trigger operations must do so as soon as possible; i.e., they cannot wait and become embedded by further structure-building. From a historical perspective, Featural Cyclicity is similar to the *Cyclic Principle* of classic transformational grammar (cf., e.g., Perlmutter and Soames (1979)): When two operations can be carried out, where one applies to the cyclic domain D_x and the other applies to the cyclic domain D_{x-1} included in D_x, then the latter is applied first. Note that the Cyclic Principle and the Strict Cycle Condition are far from the same thing: A rule applying in a higher cycle may change the context for the application of a rule in a lower cycle, such that, e.g., the second rule can now apply

(as part of the higher cycle). This interaction is excluded by the Strict Cycle Condition, but not by the Cyclic Principle.

The different predictions of the Strict Cycle Condition on the one hand and Featural Cyclicity and the Cyclic Principle on the other are striking. Numerous counter-cyclic operations that have been proposed are incompatible with the former constraint but compatible with the latter ones, among them late adjunction of adjuncts (Lebeaux (1988), Epstein et al. (1998) vs. Chomsky (2004)); wholesale later merger (Takahashi and Hulsey (2009), Urk (2015) vs. Chomsky (2019)); tucking in (Richards (2001)); head movement as adjunction (cf. Chomsky (1995), Matushansky (2006), Georgi and Müller (2010) for alternatives); and feature inheritance (Chomsky (2008), Richards (2007)).

Like the A-over-A Principle and the Superiority Condition, the Strict Cycle Condition qualifies as a good constraint according to (3). It is simple and not restricted to particular categories; it is not complex; it brings about a massive reduction of accessible space for items that can trigger operations; and by doing this and ensuring maximal stability of linguistic objects created in the course of the derivation, it looks like a good candidate for a principle of efficient computation.

12.4.2.2 The Phase Impenetrability Condition

Another fundamental constraint imposing rigid locality on operations is the Phase Impenetrability Condition (PIC) introduced in Chomsky (2000, 108) and Chomsky (2001, 13), and adopted in much subsequent minimalist work. The more restrictive version of the two PICs Chomsky considers is given in (20).[11]

(20) *Phase Impenetrability Condition* (PIC):
The domain of a head X of a phase XP is not accessible to operations outside XP; only X and its edge are accessible to such operations.

The edge of a head X is the residue outside of X′; it comprises specifiers of X (and adjuncts to XP). Chomsky (2000; 2001; 2008) proposes that phases are the clause (CP) and the predicate with its core arguments (vP). It follows from the PIC that all material that needs to be accessible outside the current phase must occur in the edge domain of the phase or on the phase head. For non-local movement operations ending beyond the current phase (as they can be found in most languages), this requires an intermediate step to a specifier of the phase head; for non-local agreement operations (as they can be found in some languages, like Hindi, Tsez, Itelmen, and Hinuq), the PIC may suggest a concept like cyclic Agree (Legate (2005)) or piggybacking of agreement on movement (Polinsky and Potsdam (2001)).[12]

Crucially, the PIC can act as a locality constraint on movement and have substantial effects here, but only if it is accompanied by a theory of what can, and what cannot, undergo movement to the phase edge. Pertinent suggestions include specific restrictions on the insertion of edge features as triggers for intermediate movement steps (see Müller (2011)) and, more recently, an Anti-Locality Constraint that prohibits items from reaching the phase edge that are too close to it (see the references in footnote 4).

Like the Strict Cycle Condition, the PIC qualifies as a good constraint in the sense of (3). It is a local constraint, hence, not complex. It clearly leads to a massive reduction of search space. It was explicitly introduced by Chomsky (2000; 2001) as a principle of efficient computation. And it is also simple and general. In particular, it can be observed that

even though it singles out CPs and vPs as phases, this does not have to be stipulated but follows because these two categories form a natural class defined by the independently motivated feature "propositional."[13]

As with the two relativized locality constraints, the two rigid locality constraints highlighted in this section form two sides of the same coin. The Strict Cycle Condition and the Phase Impenetrability Condition both reduce search space, but whereas the Strict Cycle Condition imposes restrictions on the position of an item that triggers an operation ([•F•], [∗F∗]), the PIC imposes restrictions on the position of an item that is sought by the trigger ([F]). The small size of the accessible window in syntactic derivations resulting from these two constraints, and the constant change of this window in the course of the derivation, are illustrated in (21) (where phases are underlined).

(21) *Search space reduction*:

a. $\overbrace{\underbrace{[_{YP}\ldots Y\ [_{\underline{XP}}\ldots[_{X'}X}_{PIC}}^{SCC}\ [_{WP}\ldots W\ [_{\underline{UP}}\ldots U\ldots\ ]]]]]$

b. $\overbrace{\underbrace{[_{\underline{ZP}}\ldots Z\ [_{YP}\ldots Y\ [_{\underline{XP}}\ldots[_{X'}X}_{PIC}}^{SCC}\ [_{WP}\ldots W\ [_{\underline{UP}}\ldots U\ldots\ ]]]]]$

To conclude, Chomsky's A-over-A Principle, Superiority Condition, Strict Cycle Condition, and Phase Impenetrability Condition are four constraints on grammatical dependencies that have widely been adopted in recent work on syntax, and that can be classified as good constraints according to natural criteria related to simplicity, generality, complexity, domain dependence, and efficient computation. In a nutshell, these constraints ensure that all grammatical dependencies obey minimality in syntactic structures, and that the active parts of syntactic structures that need to be considered are extremely small to begin with.

More generally, Chomsky's legacy in this domain emerges as enormous: He was the first to see that there need to be constraints on grammatical dependencies; he has insisted that constraints should not be surface-oriented statements that merely lead to descriptive adequacy, but should instead be conceived of as abstract, simple principles that meet criteria like those in (3); and he has proposed a set of such constraints himself over the decades that form a core part of synctactic theory to this day.

Endnotes

1 Note that this conclusion is independent of the specific approach to syntactic structure-building chosen. Thus, if basic structure-building and displacement are not brought about by external and internal Merge, but rather by context-free phrase structure rules and designated transformations (which map syntactic trees onto other syntactic trees), respectively, as in classical transformational grammar (which of course formed the background to Chomsky's original considerations), the need for constraints arises in exactly the same way.

2 The *Subjacency Condition* (see Chomsky (1977; 1986a)) was introduced in order to derive effects covered by constraints like the CNPC and the Wh-Island Condition, by prohibiting movement that crosses two bounding nodes; the set of bounding nodes may vary from

one language to another (see Rizzi (1982)). This two-node condition, while certainly an improvement over Ross's original constraints, can also easily be shown to violate the requirements in (3).

3 An extended google scholar search in early 2020 yields almost 7000 hits for articles or books containing "ECP" and "Chomsky."

4 A general *Anti-Locality Constraint* (see Bošković (1994; 2014), Grohmann (2000; 2003), Grohmann and Nevins (2004), Abels (2003; 2012), Erlewine (2016), Pesetsky (2016)) can block subject movement as too short where object movement in the same context is sufficiently non-local, and might thus ultimately be a candidate for this role.

5 From a contemporary point of view based on incremental structure-building via Merge, the most restrictive concept of a cyclic domain is the current root in a given derivation.

6 In view of Ross's counter-arguments, Postal (2012) takes this constraint to be a "failed principle," a "bankrupt idea," and criticizes Chomsky for not abandoning the A-over-A Principle after Ross (1967). As we will see momentarily, both Postal's assessment of the status of the A-over-A Principle and his criticism of Chomsky based on it are misguided.

7 However, see also Chomsky et al. (2019), Safir (2019) and literature cited there for the opposite view, essentially the "Affect-α" view of standard government-and-binding theory (Lasnik and Saito (1992)).

8 A category α c-commands another category β iff the next category containing α also contains β, and neither contains the other; see Reinhart (1976). Accordingly, α asymmetrically c-commands β if α c-commands β, and β does not c-command α.

9 Indeed, explicitly general minimality constraints that are virtually indistinguishable from (15) have been proposed subsequently, by Fanselow (1990; 1991) and by Ferguson (1993) and Ferguson and Groat (1994). Note incidentally that Rizzi's (1990) Relativized Minimality, which at first sight may seem similar to (15), is very different both conceptually and in its empirical consequences; see Müller (2011, 61–64).

10 Versions of the constraint include the *Extension Condition* in Chomsky (1995), and the *No Tampering Condition* in Chomsky (2008).

11 Koster's (1978) *Bounding Condition* and Riemsdijk's (1978) *Head Constraint* can be viewed as predecessors.

12 Alternatively, Chomsky et al. (2019) suggest that the complement of a phase head might remain accessible throughout; it cannot be modified, but goal features in this domain can be accessed for Agree relations.

13 Basically the same conclusion holds if *all* XPs are viewed as phases (Müller (2011)); arguably, some additional effort is required from this perspective to motivate proposals where only CP is a phase (Keine (2016)); where DP is a phase in addition to CP and vP (Matushansky (2005), Kramer (2007)); where TP can be a phase (Richards (2011)); or where phase status is more flexible (Bobaljik and Wurmbrand (2003), Marušič (2005), den Dikken (2007), Gallego (2007)).

References

Abels, Klaus. 2003. *Successive Cyclicity, Anti-Locality, and Adposition Stranding*. PhD thesis, Storrs: University of Connecticut.

Abels, Klaus. 2012. *Phases. An Essay on Cyclicity in Syntax*, volume 543 of *Linguistische Arbeiten*. Berlin: De Gruyter.

Aoun, Joseph, Norbert Hornstein, and Dominique Sportiche. 1981. Aspects of wide scope interpretation. *Journal of Linguistic Research* 1:69–95.

Assmann, Anke, Doreen Georgi, Fabian Heck, Gereon Müller, and Philipp Weisser. 2015. Ergatives move too early. On an instance of opacity in syntax. *Syntax* 18:343–387.

Bobaljik, Jonathan and Susanne Wurmbrand. 2003. Relativized phases. Ms., Storrs: University of Connecticut.

Bošković, željko. 1994. D-structure, theta-criterion, and movement into theta positions. *Linguistic Analysis* 24:247–286.

Bošković, željko. 2014. Now I'm a phase, now I'm not a phase: On the variability of phases with extraction and ellipsis. *Linguistic Inquiry* 45:27–89.

Bošković, željko and Howard Lasnik. 1999. How strict is the cycle? *Linguistic Inquiry* 20:691–703.

Bresnan, Joan. 1976. On the form and functioning of transformations. *Linguistic Inquiry* 7:3–40.

Browning, Marguerite. 1991. Bounding conditions on representations. *Linguistic Inquiry* 22:541–562.

Chomsky, Noam. 1957. *Syntactic Structures*. The Hague and Paris: Mouton.

Chomsky, Noam. 1964a. *Current Issues in Linguistic Theory*. The Hague: Mouton.

Chomsky, Noam. 1964b. The logical basis of linguistic theory. In H. Lunt, editor, *Proceedings of the Ninth International Congress of Linguists, Cambridge, Mass.* The Hague: Mouton and Co.

Chomsky, Noam. 1973. Conditions on transformations. In Stephen Anderson and Paul Kiparsky, editors, *A Festschrift for Morris Halle*, pages 232–286. New York: Academic Press.

Chomsky, Noam. 1975. *The Logical Structure of Linguistic Theory*. New York: Plenum Press.

Chomsky, Noam. 1977. On wh-movement. In Peter Culicover, Tom Wasow, and Adrian Akmajian, editors, *Formal Syntax*, pages 71–132. New York: Academic Press.

Chomsky, Noam. 1981. *Lectures on Government and Binding*. Dordrecht: Foris.

Chomsky, Noam. 1982. *The Generative Enterprise. A Discussion with Riny Huybregts and Henk van Riemsdijk*. Dordrecht: Foris Publications.

Chomsky, Noam. 1986a. *Barriers*. Cambridge: MIT Press.

Chomsky, Noam. 1986b. *Knowledge of Language*. New York: Praeger.

Chomsky, Noam. 1995. *The Minimalist Program*. Cambridge: MIT Press.

Chomsky, Noam. 2000. Minimalist inquiries: The framework. In Roger Martin, David Michaels, and Juan Uriagereka, editors, *Step by Step*, pages 89–155. Cambridge: MIT Press.

Chomsky, Noam. 2001. Derivation by phase. In Michael Kenstowicz, editor, *Ken Hale. A Life in Language*, pages 1–52. Cambridge: MIT Press.

Chomsky, Noam. 2002. *On Nature and Language*. Cambridge: Cambridge University Press.

Chomsky, Noam. 2004. Beyond explanatory adequacy. In Adriana Belletti, editor, *Structures and Beyond. The Cartography of Syntactic Structures*, volume 3, pages 104–131. Oxford: Oxford University Press.

Chomsky, Noam. 2005. Three factors in language design. *Linguistic Inquiry* 36:1–22.

Chomsky, Noam. 2008. On phases. In Robert Freidin, Carlos Otero, and Maria Luisa Zubizarreta, editors, *Foundational Issues in Linguistic Theory*, pages 133–166. Cambridge: MIT Press.

Chomsky, Noam. 2013. Problems of projection. *Lingua* 130:33–49.

Chomsky, Noam. 2019. Lectures. UCLA & MIT.

Chomsky, Noam and Howard Lasnik. 1977. Filters and control. *Linguistic Inquiry* 8: 425–504.

Chomsky, Noam, Ángel Gallego, and Dennis Ott. 2019. Generative grammar and the faculty of language: Insights, questions, and challenges. *Catalan Journal of Linguistics* Special Issue:229–261.

Cinque, Guglielmo. 1990. *Types of A-bar Dependencies*. Cambridge, Mass: MIT Press..

Collins, Chris. 1997. *Local Economy*. Cambridge: MIT Press.

Collins, Chris and Edward Stabler. 2016. A formalization of minimalist syntax. *Syntax* 19(1):43–78.

den Dikken, Marcel. 2007. Phase extension: Contours of a theory of the role of head movement in phrasal extraction. *Theoretical Linguistics* 33:1–41.

Epstein, Sam, Erich Groat, Ruriko Kawashima, and Hisatsugu Kitahara. 1998. *A Derivational Approach to Syntactic Relations*. Oxford and New York: Oxford University Press.

Erlewine, Michael. 2016. Anti-locality and optimality in Kaqchikel agent focus. *Natural Language and Linguistic Theory* 34:429–479.

Fanselow, Gisbert. 1987. *Konfigurationalität*. Tübingen: Narr.

Fanselow, Gisbert. 1990. On the nature of proper government and syntactic barriers. In Werner Abraham, Wim Kosmeijer, and Eric Reuland, editors, *Issues in Germanic Syntax*, pages 33–48. Berlin: Mouton De Gruyter.

Fanselow, Gisbert. 1991. Minimale Syntax. Habilitation thesis, Universität Passau.

Scott Ferguson, K. 1993. Notes on the shortest move metric and object checking. *Harvard Working Papers in Linguistics* 3:65–80.

Ferguson, Scott and Erich Groat. 1994. Defining "shortest move." Ms., Harvard University.

Fiengo, Robert. 1977. On trace theory. *Linguistic Inquiry* 8:35–61.

Fitzpatrick, Justin. 2002. On minimalist approaches to the locality of movement. *Linguistic Inquiry* 33:443–463.

Fox, Danny and David Pesetsky. 2005. Cyclic linearization of syntactic structure. *Theoretical Linguistics* 31:1–45.

Frampton, John and Sam Gutmann. 1999. Cyclic computation. *Syntax* 2:1–27.

Freidin, Robert. 1992. *Foundations of Generative Syntax*. Cambridge: MIT Press.

Freidin, Robert. 1999. Cyclicity and minimalism. In Samuel David Epstein and Norbert Hornstein, editors, *Working Minimalism*, pages 95–126. Cambridge: MIT Press.

Fukui, Naoki. 1997. Attract and the A-over-A Principle. *UCI Working Papers in Linguistics* 3:51–67.

Gallego, Ángel. 2007. *Phase Theory and Parametric Variation*. PhD thesis, Barcelona: Universitat Autónoma de Barcelona.

Gallego, Ángel. 2020. Strong and weak "strict cyclicity" in phase theory. Ms., Universitat Autònoma de Barcelona.

Gazdar, Gerald. 1982. Phrase structure grammar. In *The Nature of Syntactic Representation*, pages 131–186. Dordrecht: Reidel.

Georgi, Doreen. 2017. Patterns of movement reflexes as the result of the order of Merge and Agree. *Linguistic Inquiry* 48(4):585–626.

Georgi, Doreen and Gereon Müller. 2010. Noun phrase structure by reprojection. *Syntax* 13(1):1–36.

Graf, Thomas. 2013. *Local and Transderivational Constraints in Syntax and Semantics*. PhD thesis, UCLA.

Grimshaw, Jane. 1998. Constraints on constraints in optimality theoretic syntax. Ms., New Brunswick, NJ: Rutgers University.

Grohmann, Kleanthes and Andrew Nevins. 2004. On the syntactic expression of pejorative mood. *Linguistic Variation Yearbook* 4:137–179.

Grohmann, Kleanthes K. 2000. *Prolific Peripheries: A Radical View From the Left*. PhD thesis, University of Maryland.

Grohmann, Kleanthes K. 2003. Successive cyclicity under (anti-)local considerations. *Syntax* 6:260–312.

Haegeman, Liliane. 1995. *An Introduction to Government and Binding Theory*. 2 edition, Oxford: Blackwell.

Hauser, Marc, Noam Chomsky, and W. Tecumseh Fitch. 2002. The faculty of language: What is it, who has it, and how did it evolve? *Science* 298: 1569–1579.

Heck, Fabian. 2008. *On Pied-Piping. Wh-Movement and Beyond*, volume 98 of *Studies in Generative Grammar*. Berlin: Mouton de Gruyter.

Hornstein, Norbert. 2009. *A Theory of Syntax: Minimal Operations and Universal Grammar*. Cambridge: Cambridge University Press.

Hornstein, Norbert, Jairo Nũnes, and Kleanthes Grohmann. 2005. *Understanding Minimalism*. Cambridge: Cambridge University Press.

Huang, Cheng-Teh James. 1982. *Logical Relations in Chinese and the Theory of Grammar*. PhD thesis, Cambridge: MIT.

Jacobson, Pauline and Paul Neubauer. 1974. Extraposition rules and the cycle. In *Berkeley Studies in Syntax and Semantics*, volume 1:viii, pages 1–99.

Keine, Stefan. 2016. *Probes and Their Horizons*. PhD thesis, Amherst: University of Massachusetts.

Kitahara, Hisatsugu. 1997. *Elementary Operations and Optimal Derivations*. Cambridge: MIT Press.

Koizumi, Masatoshi. 1995. *Phrase Structure in Minimalist Syntax*. PhD thesis, Cambridge: MIT.

Koster, Jan. 1978. *Locality Principles in Syntax*. Dordrecht: Foris.

Kramer, Ruth. 2007. The Amharic definite marker and the syntax/PF interface. Ms., Santa Cruz: University of California.

Kuno, Susumo. 1973. Constraints on internal clauses and sentential subjects. *Linguistic Inquiry* 4:363–385.

Lakoff, George. 1971. On generative semantics. In Danny Steinberg and Leon Jakobovits, editors, *Semantics*, pages 232–296. Cambridge: Cambridge University Press.

Lasnik, Howard and Mamoru Saito. 1984. On the nature of proper government. *Linguistic Inquiry* 15:235–289.

Lasnik, Howard and Mamoru Saito. 1992. Move α. Cambridge: MIT Press.

Lebeaux, David. 1988. *Language Acquisition and the Form of the Grammar*. PhD thesis, Amherst: University of Massachusetts.

Legate, Julie Anne. 2005. Phases and cyclic agreement. *MITWPL* 49:147–156. Perspectives on Phases.

Lohndal, Terje. 2010. Freezing effects and objects. *Journal of Linguistics* 47:163–199.

Marušič, Franc. 2005. *On Non-Simultaneous Phases*. PhD thesis, Stony Brook University.

Matushansky, Ora. 2005. Going through a phase. *MITWPL* 49:157–181. Perspectives on Phases.

Matushansky, Ora. 2006. Head-movement in linguistic theory. *Linguistic Inquiry* 37: 69–109.

McCawley, James. 1984. Exploitation of the cyclic principle as a research strategy in syntax. In Wim de Geest and Y Putseys, editors, *Sentential Complementation*, pages 165–183. Dordrecht: Foris.

McCawley, James. 1998. *The Syntactic Phenomena of English*. Chicago: University of Chicago Press.

Medeiros, David. 2008. Optimal growth in phrase structure. *Biolinguistics* 2:152–195.

Müller, Gereon. 1998. *Incomplete Category Fronting*. Dordrecht: Kluwer.

Müller, Gereon. 2004. Argument encoding and the order of elementary operations. Ms., Universität Leipzig.

Müller, Gereon. 2011. *Constraints on Displacement. A Phase-Based Approach*, volume 7 of *Language Faculty and Beyond*. Amsterdam: Benjamins.

Müller, Gereon. 2014. *Syntactic Buffers*, volume 91. Linguistische Arbeits Berichte, Universität Leipzig.

Müller, Gereon and Wolfgang Sternefeld. 2001. The rise of competition in syntax: A synopsis. In Gereon Müller and Wolfgang Sternefeld, editors, *Competition in Syntax*, pages 1–68. Berlin: Mouton de Gruyter.

Perlmutter, David and Scott Soames. 1979. *Syntactic Argumentation and the Structure of English*. Berkeley: The University of California Press.

Pesetsky, David. 1982. *Paths and Categories*. PhD thesis, Cambridge: MIT.

Pesetsky, David. 2013. Phrasal movement and its discontents: Diseases and diagnoses. In Lisa Cheng and Norbert Corver, editors, *Diagnostics for Movement*, pages 123–157. Oxford: Oxford University Press.

Pesetsky, David. 2016. Exfoliation: Towards a derivational theory of clause size. Ms., Cambridge: MIT.

Pesetsky, David and Esther Torrego. 2006. Probes, goals and syntactic categories. Ms., MIT. Lingbuzz/000321.

Polinsky, Maria and Eric Potsdam. 2001. Long-distance agreement and topic in Tsez. *Natural Language and Linguistic Theory* 19:583–646.

Postal, Paul. 2012. Two case studies of Chomsky's play acting at linguistics. Ms., Lingbuzz.

Preminger, Omer. 2018. How to tell a syntactic phenomenon when you see it. Ms., University of Maryland.

Pullum, Geoffrey. 1979. *Rule Interaction and the Organization of a Grammar*. New York: Garland.

Pullum, Geoffrey. 1992. The origins of the Cyclic Principle. In *Proceedings of the Regional Meeting of the Chicago Linguistic Society*, volume 28.2, pages 209–236.

Rackowski, Andrea and Norvin Richards. 2005. Phase edge and extraction. *Linguistic Inquiry* 36:565–599.

Reinhart, Tanya. 1976. *The Syntactic Domain of Anaphora*. PhD thesis, Cambridge: MIT.

Richards, Marc. 2007. On feature inheritance. *Linguistic Inquiry* 38:563–572.

Richards, Marc. 2011. Deriving the edge: What's in a phase? *Syntax* 14:74–96.

Richards, Norvin. 2001. *Movement in Language*. Oxford: Oxford University Press.

van Riemsdijk, Henk. 1978. *A Case Study in Syntactic Markedness: The Binding Nature of Prepositional Phrases*. Dordrecht: Foris.

van Riemsdijk, Henk and Edwin Williams. 1986. *Introduction to the Theory of Grammar*. Cambridge: MIT Press.

Rizzi, Luigi. 1982. *Issues in Italian Syntax*. Dordrecht: Foris.

Rizzi, Luigi. 1990. *Relativized Minimality*. Cambridge: MIT Press.

Ross, John. 1967. *Constraints on Variables in Syntax*. PhD thesis, Cambridge: MIT.

Safir, Ken. 2019. The A/A-bar distinction as an epiphenomenon. *Linguistic Inquiry* 50:285–336.

Sauerland, Uli. 1999. Erasability and interpretation. *Syntax* 3:161–188.

Takahashi, Shoichi and Sarah Hulsey. 2009. Wholesale late merger: Beyond the A/A-bar distinction. *Linguistic Inquiry* 40:387–426.

Takano, Yuji. 1994. Unbound traces and indeterminacy of derivation. In Masaru Nakamura, editor, *Current Topics in English and Japanese*, pages 229–253. Tokyo: Hituzi Syobo.

van Urk, Coppe. 2015. *A Uniform Syntax for Phrasal Movement: A Dinka Bor Case Study*. PhD thesis, Cambridge: MIT.

Vicente, Luis. 2007. *The Syntax of Heads and Phrases*. PhD thesis, LOT: Netherlands Graduate School of Linguistics, Universiteit Leiden.

Wasow, Tom. 1972. *Anaphoric Relations in English*. PhD thesis, Cambridge: MIT.

Wexler, Ken and Peter Culicover. 1980. *Formal Principles of Language Acquisition*. Cambridge: MIT Press.

Zaenen, Annie and Jessie Pinkham. 1976. The discovery of another island. *Linguistic Inquiry* 7:652–664.

13

Chomsky's Influence on Historical Linguistics: From Universal Grammar to Third Factors

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13.1 Introduction

Chomsky's influence on historical linguistics is huge, starting with the work by Edward Klima, Robert King, Henning Andersen, Elizabeth Closs-Traugott, and Paul Kiparsky who emphasize the role of acquisition in language change and use the transformational generative model to understand earlier stages of languages. Subsequent work by, for instance, David Lightfoot, Ian Roberts and Anna Roussou, and Elly van Gelderen employs more recent versions of generative linguistics to understand linguistic change. The aim of this chapter is to briefly sketch some earlier work (see van Gelderen 2015; 2016 for more) and then to review a few of the recent trends in more detail.

Although this chapter is mainly concerned with Chomsky's influence on historical linguistics, one might also ask about the influence of historical linguistics on Chomskyan thought. This influence is unfortunately small. The reason is that Chomsky's work emphasizes innate linguistic knowledge and focuses on the ability of native speakers to speak and understand grammatical sentences, something we cannot check for at earlier stages of language. I show that the influence is minimal, but will illustrate how work in historical linguistics has, in fact, consistently provided insight to different instantiations of work in generative grammar.

The outline is as follows. In section 13.2, I outline the tension between Chomskyan generative grammar and historical linguistics and argue how both have been beneficial to each other. In section 13.3, I describe how generative grammar has changed from an emphasis on very specific transformations and phrase structure rules to more generalizable Principles and Parameters, to a Minimalist outlook and how these developments have changed the way historical linguists consider data. Sections 13.4 and 13.5 show how Third Factor Principles shape language change and section 13.6 is a conclusion evaluating Chomsky's influence.

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13.2 Generative Grammar and Historical Linguistics

Generative grammar and historical linguistics can benefit from each other's insights. The direction of influence has been rather one-sided, unfortunately – from generative grammar to historical linguistics.

Generative grammar is interested in how children acquire a grammar on the basis of the language they are exposed to. As a result of external social and cultural changes, the language a child hears can be different from that which their parents/caregivers grew up, with and the child can internalize a different grammar. More interestingly, language change can also occur because children construct an internal grammar, based on innate principles, that is different from that of their parents and when that grammar continues to adulthood.

Over the 60 years that generative grammar has been around, it has changed its views on what is innate and on how sentences are derived. If we take the change from Old English object–verb (OV) order in (1a) to Middle English verb–object (VO) order in (1b), early generative grammar would have had different phrase structure rules that a child would posit: (2a) in Old English and (2b) in Middle English.

(1)	a.	*hu*	*ðа*	*æþelingas*	*ellen*	***fremedon***	OV
		how	those	nobles	courage	did	
		"how the noble ones accomplished courageous deeds" (*Beowulf*, 499–500, van Gelderen 2018b: 33)					
	b.	*The ni3tingale* ***bigon*** *the speche. in one hurne of one breche.*					VO
		"The nightingale began the argument in the corner of a clearing." (*Owl*, 13–4, van Gelderen 2018b: 115)					

(2)	a.	VP	→	(NP)	V	
	b.	V	→	V	(NP)	(adapted from Chomsky 1965, p. 85)

During the subsequent Principles and Parameters phase (Chomsky 1981), the change from OV to VO was seen in terms of children setting their innate parameters as head-initial, where their parents had head-final. More recent versions see the OV/VO divide as triggered by features present in the functional categories in some languages but not in others.

There are also many ways in which language change can provide insights into the (generative) language faculty. For instance, there are changes that have never been attested and that therefore show restrictions imposed by the Faculty of Language. In turn, frequently attested changes shed light on the principles that help acquire a grammar. An example of a common cross-linguistic change is that prepositions are reanalyzed as complementizers (e.g. *for* and *after* in the history of English but, interestingly, not the other way around). This unidirectional change is named grammaticalization, because the preposition loses phonological and semantic information and becomes more grammatical, as a complementizer (e.g. it no longer has a synonym or antonym in (3b)). The preposition in (3a) is earlier than the complementizer in (3b) and, similarly, the preposition in (4a) is attested earlier than the complementizer in (4b). The prepositional use is typical of Old English (and later), whereas the first instances of complementizer use are later than Old English.

(3) a. hlynode ***for*** hlawe
made noise before mound
"It made noise before/around the gravehill" (*Beowulf* 1120).
b. They would prefer **for** him to focus on the economy. (COCA 2017)

(4) a. Ercenberht rixode ***æfter*** his fæder
"E. ruled after/following his father" (*Anglo Saxon Chronicle A*, anno 640, Thorpe).
b. **After** they were removed, the vote itself was in doubt. (COCA 2017)

The change from preposition to complementizer shows an intermediate stage where the entire prepositional phrase is preposed, as in (5). Once a PP is preposed, its structure is reanalyzed as a C head and its function in a higher position in the clause, i.e. as complementizer.

(5) ***Æfter þæm*** *Iulius for to Rome & bæd …*
"After that Julius went to Rome and asked … " (Orosius, 126.11)

The change from PP to C shows us Economy Principles at work, namely, a complementizer head is simpler in structure than a phrase.

There has been a group of generative linguists[1] interested in historical change, arguing that such change gives a special insight into the innate language faculty. A good example is Allen (1977), who, working with nonelectronic texts, finds instances relevant to *wh*-extraction. In (6), the *wh*-word *hwaet* has been moved from the position of subject of the predicate *sie forcuðre* to the beginning of the sentence.

(6) *Ac* *hwaet* *saegst* *ðu* *ðonne* ***ðaet*** — ***sie*** *forcuðre*
But what say you then that be wickeder
ðonne *sio* *ungesceadwisnes?*
than be foolishness
"But what do you say is wickeder than foolishness?"
(Boethius 36.8, from Allen 1977, p. 122)

For many speakers, this movement results in an ungrammatical sentence in Modern English, as (7) shows, when it leaves *that* adjacent to the gap – a *that*-trace violation – but not in Old English.

(7) *what do you say that __ is wickeder than is foolishness.

Showing this difference was an important result for generative models that claimed universal ungrammaticality. Others showed this for synchronic stages, e.g. Perlmutter (1971) and Maling and Zaenen (1978).

However, possibly because of the early emphasis on introspection and grammaticality judgments by a native speaker, work in historical generative syntax is not mentioned or referred to in Chomsky. The exception is the work on phonological change in Chomsky and Halle (1968), and that was most likely due to Halle's (1962) interests. Since

Chomsky has set the agenda for generative linguists for at least 60 years, it has been less popular to pursue historical linguistics. Many generative conferences and journals do not see historical linguistics as a crucial component to their enterprise of understanding the faculty of language. Apart from the DiGS conference (see footnote 1), other venues are generative or historical but not both. For instance, NELS (North East Linguistic Society) and WCCFL (West Coast Conference on Formal Linguistics) are prominent generative conferences in the United States and rarely include historical work.

In conclusion, in this section, I have mentioned how there is a great deal of influence of Chomskyan, generative linguistics on historical linguistics, in particular syntax. The next sections will chronicle a few more such cases. The influence in the other direction is less obvious. The absence of native speakers of Old English to check sentences like (6) and the reliance on written texts and (now) electronic corpora kept some generative grammarians from trusting historical data. However, there are insights to be gained from historical data into the language faculty.

13.3 From Principles and Parameters to Third Factors

Generative grammar has evolved in the last 60 years, from Transformational Generative Grammar of the 1960s to the Principles and Parameters (P&P) model of the 1980s and 1990s to cartography and the Minimalist Program of the 1990s to the present Problems of Projection (PoP) model, with its special attention to Third Factors.

Since Chomsky (1981), the Principles and Parameters approach has provided a way to say what all languages have in common and where they differ. Principles hold true for all languages and include, for instance, the basic shape of phrases (with a head and a complement), the requirement that movement is local, and that sentences are hierarchically, rather than linearly, structured. Parameters account for cross-linguistic differences and are to be set depending on the evidence the learner encounters. If, for instance, the language the learner hears the object before the verb, the parameter is set as verb-final. Early examples of parameters include determining if a language has pro-drop (Rizzi 1982), its headedness (e.g. verb-last or verb-first), and whether *wh*-elements move or not. There was important diachronic work in the period from the mid-1970s to the early 1990s on word order, headedness, functional categories, and movement. Canale (1978) argues that Old English changes its headedness around 1200 when it changes from an OV to VO language (although earlier in some texts and later in others). Pintzuk (1991) looks at the position of the I(nflection) position (now T(ense)) in Old English, Roberts (1993) at verb-movement, and auxiliaries, Kiparsky (1996) at V-to-C movement in early Indo-European and Germanic, and Eyþórrson (1995) at early Germanic verb-movement.

Old English (8) shows a null subject and this can be accounted for by the pro-drop parameter, conditioned by the licensing through overt agreement on the verb; here plural. Old English sets the parameter to positive, allowing pro-drop, where later English changes to a negative setting[2].

(8) *Nu* *scylun* *hergan* *hefaenricaes* *uard*
Now must.PL praise heavenly_kingdom guard
"Now we must praise the lord of the heavenly kingdom." (Northumbrian Caedmon's Hymn, 1).

Exploring the position of I(nflection) or T(ense), Verb-movement, auxiliaries in relation to verbs leads to an examination of the inventory and order of the functional categories. Work on infinitival *to* (van Gelderen 1993; Los 2005), determiners (Philippi 1997), complementizers (van Gelderen 2011a), the position of the I (Pintzuk 1991), and auxiliaries (Warner 1993) shows that languages differ in their inventories and this leads ultimately to the Borer-Chomsky Conjecture that "all parameters of variation are attributable to differences in the features of particular items (e.g. the functional heads) in the lexicon" (Baker 2008: 156). If the I in (8) has certain features for person and number, the overt pronoun is not needed. Other cases of variation involve the presence or absence of gender on the D, which differentiates, e.g. Spanish from English.

The emphasis on position of functional categories co-evolves with cartographic approaches that aim to provide a unique position for each functional category (Rizzi 1997; Cinque 1999). Old English embedded clauses show a less expanded subordinate clause, as in (9), compared to Modern English (10). In (9), there is a complementizer *þæt* but, in (10), there is a complementizer, an adverb, and an auxiliary that link the two sentences

(9) *Ealle þas goldsmiðas secgað* ***þæt*** *hi næfre ær … ne gesawon.*
All those goldsmiths say that they never before … not saw
"The goldsmiths say that they never before saw (such a piece of gold)."
(DOE, *Ælfric's Catholic Homilies*, Clemoes 209.92)

(10) … made it very clear **that never did** he come home with any bruises, … (COCA 2009 ABC news)

The focus of the Minimalist Program is on principles not specific to the language faculty, on "general properties of organic systems" (Chomsky 2004: 105), labeled "Third Factor Principles" in Chomsky (2005; 2007). For instance, Chomsky (e.g. 2004; 2007) and Richards (2008) attribute as little as possible to the role of parameters and to Universal Grammar (UG) in general. Apart from this move away from language-specific parameters, a second change is that Minimalist parameters consist of choices of feature specifications as the child acquires a lexicon. Thus, a Chinese learner includes ASP(ect) but an English one incorporates Tense. All parameters are lexical and determine the linear order of the words, thereby accounting for the variety of languages. As Pintzuk et al (2000, p. 7) put it, "the lexicon … must be the locus of syntactic change."

In van Kemenade and Vincent (1997), we can see the beginning of the shift towards Minimalism with its emphasis on morphosyntactic features. Most of the papers, however, continue to be in the P&P framework, as do those in Pintzuk, Tsoulas, and Warner (2000). Typical topics are null arguments, negatives and polarity, position of subjects, the change to VO order, and verb-movement. Thus, in the 1990s, historical generative syntax continues to be concerned with clause structure and the parameter of verb-movement.

Both developments, the move toward general (Third Factor) principles and toward parametric features, make it easier to account for *grammaticalization,* a very frequent change that was left unexplored in early generative work (e.g. in Allen 1977; Lightfoot 1979; van Kemenade 1987). Third Factor Principles include Economy Principles, such as "don't posit too much structure" and "don't allow choice" (also known as "Determinacy" or "Restrict Resources," in Chomsky 2019). The change from preposition to

complementizer involves a reanalysis of phrases to heads, e.g. in the case of PPs in (4a) to complementizer heads in (4b), repeated here.

(4) a. *Ercenberht rixode* ***æfter*** *his fæder*
"E. ruled after/following his father" (*Anglo Saxon Chronicle A*, anno 640, Thorpe).
b. **After** they were removed, the vote itself was in doubt. (COCA 2017)

A simplification from phrases to heads is also involved in the change from pronouns to clitics and agreement, as shown in section 13.4.

The change in direction to focus on features has made two initiatives possible: one to account for grammaticalization in terms of features and a second to account for word order in that way. Van Gelderen (2011a) argues that grammaticalization can be understood as a change from semantic to formal features. An Old English verb such as *wille* "want" in (11a) has [volition, expectation, intention] as its semantic features. These features are simplified when *will* is reanalyzed as only having the grammatical feature [i-future] in (11b). This is represented in (12), where i- stands for interpretable feature.

(11) a. *Ic sceal hraðe* ***cunnan*** *hwæt ðu us to duguðum gedon* ***wille***.
I must swiftly know what you us to benefit do want.
"I must know quickly what you want to do to benefit us." (Andreas 341, Vercelli Book)
b. I'**ll** never forget the judge saying that Lindy would be put into jail for life … (COCA 2012 news)

(12) *will* [volition/intention] > *(wi)ll* [i-future]

Examining the shift in word order from OV to VO in (1), repeated here, Biberauer and Roberts (2008) crucially rely on the EPP-feature.

(1) a.

hu	*ða*	*æþelingas*	*ellen*	***fremedon***
how	those	nobles	courage	did

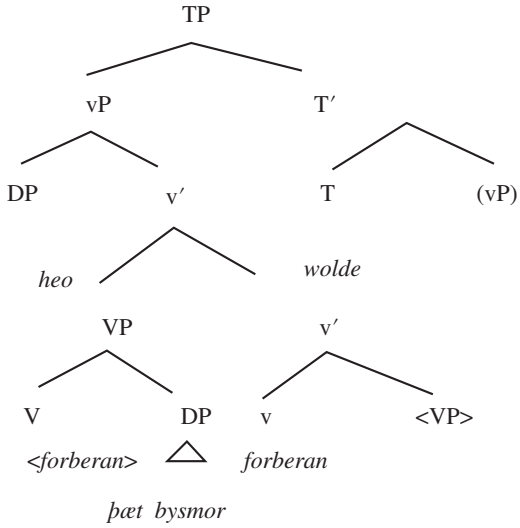
"how the noble ones accomplished courageous deeds"
b. *The ni3tingale* ***bigon*** *the speche. in one hurne of one breche*.
"The nightingale began the argument in the corner of a clearing."

This feature – in languages that have it – is responsible for making a subject move to sentence initial position. If the T(ense) position bears this feature, a D head will move to T or a DP will move to the specifier of the TP, as is the case in Modern English. Languages can also have a VP or vP to satisfy the EPP feature. This is the option chosen in Old English: the VP/vP is moved rather than stranded as it is in Modern English. Thus, Biberauer and Roberts derive the Old English OV word orders by raising the verb *forberan* "tolerate" in (13) to the light verb v, VP-raising to the specifier of vP, and vP raising to the specifier of TP, as shown in (14).

(13) *gif heo þæt bysmor forberan wolde*

if she that disgrace tolerate would
"if she would tolerate that disgrace." (ALS [Eugenia], 185.305, from Pintzuk and Taylor 2011)

(14)



In short, current generative historical linguists are using feature-checking mechanisms to account for grammaticalization and word order variation. In the next sections, I move to the most current instantiation of the Minimalist Program, Problems of Projection. These approaches have moved toward even more of an emphasis on the Third Factor Principles – the Labeling Algorithm and Indeterminacy.

13.4 Change Due to Labeling Pressure

Labeling a tree node as NP or VP used to be an automatic part of the syntax. Phrase structure rules, as in (2), start with a label, in fact. Chomsky's current focus (2013; 2015) on labeling as a Third Factor effect necessitated by the interfaces and unconnected to Merge makes it possible to see syntactic change in another way, namely as a resolution to labeling problems.

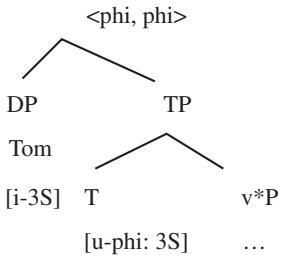
As also explained in Alexiadou and Lohndal (Chapter 3 this volume), the Labeling Algorithm (LA) operates after Merge is complete, at the time that a syntactic derivation is transferred to the interfaces. When a head and a phrase merge in (15), the LA determines that the head is the label.

(15) Merge *the* and *red apple*: DP {the, {red, apple}}

Where two phrases merge, the LA cannot find the head and one of the phrases either has to move or share features with the other. In certain cases, the heads of the phrases

share phi-features (or Q-features) and the set is successfully labeled, <phi, phi> in the case of a subject in (16).

(16)



The interpretable features of the DP ([i-]) in (16) value the uninterpretable ones on the T ([u-]) but that is not crucial here.

In addition to Chomsky's resolutions (movement or sharing), van Gelderen (2018a, 2019) argues that reanalyzing a phrase as a head also resolves the labeling problem. Such reanalysis is frequent. The reanalyses of phrases as heads are varied: (a) subject and object pronouns to agreement, i.e. DPs to T and v heads, respectively, (b) demonstratives to C, D, and T heads, (c) *wh*-elements to C heads, and (d) Adverb Phrases to ASP heads, PPs to C heads, as shown in (3) to (5), and negative adverbs to Neg heads. All these changes provide insight into some of the labeling mechanisms: minimal search, as in (15), is preferred over sharing features, as in (16).

An example of a phrase being reanalyzed as a head occurs when an independent pronoun changes to an agreement head. (After the pronoun is reanalyzed as agreement, there is optional renewal in many languages to which I come back in section 13.5.) In Old French (17), the pronoun *je* need not be adjacent to the finite verb but, in Modern Spoken French (18), it does, indicating it is part of the verb.

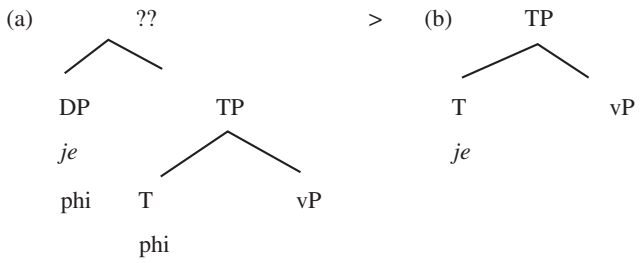
(17) *Se **je** meïsme ne li di* — Old French
If I myself not him tell
"If I don't tell him myself." (Franzén 1939:20, Cligès 993)

(18) a. ***Je** lis et **j'**-écris* — Spoken French
I read and I-write
b. **Je lis et écris*
I read and write

This and a number of other differences show that the erstwhile pronouns, such as those in (17), have been reanalyzed as agreement markers in (18a) and are now obligatory.

A scenario for the change from (17) to (18) due to labeling pressure is that the labeling in (17) of the phrasal pronoun and the clause is not as straightforward, shown by the question marks in (19a), as the labeling through a head in (19b) for (18a). In (19a), the DP and TP are both phrases so no head can be detected by the LA. That's why they have to share features. In (19b), labeling is through minimal search for a head, which is simpler.

(19)



The change discussed in this section, from DP pronoun to T agreement, shows that, even though both {XP, YP} and {X, YP} can be labeled, the latter is preferred because that labeling is just through minimal search.

13.5 Change Due to Indeterminacy

Apart from labeling, there are other Third Factor Principles, such as the one to avoid indeterminacy in a derivation. As Chomsky, Ott, and Gallego (2017: 20) put it, within a WorkSpace – read phase – there can be only one object X, "avoiding indeterminate rule application." This principle is one of economy of derivations and applies, for instance, to *wh*-extraction from the subject, as in (20).

(20) a. *Who did pictures of please you?
b. [CP who [C-did [TP [pictures of who] [T [vP [pictures of who] [v [please you]]]]]]].

The subject cannot itself be moved either, as is obvious, from the impossibility to topicalize in English (21) and provides an explanation for the *wh*-element staying in Spec TP in (22), evidenced by the lack of Subject Auxiliary Inversion.

(21) a. *John, likes berries. (Topic intonation on *John*)
b. CP[John TP[John vP[John likes berries]]].
(22) a. Who likes berries?
b. TP[who [T vP[who likes berries]]].

The ungrammaticality of (20) and (21) follows from indeterminacy: movement to the CP domain would have a choice of two copies, in Spec TP and Spec vP. Indeterminacy also stops *who* in (22) from being extracted out of a domain that has two copies in it.

In what follows, I look at the reanalysis of a topic from Spec TopP to a grammatical subject in Spec TP. Givón (1979) and others have discussed topics that are reanalyzed as subjects and call this a shift from the pragmatic to the syntactic. When French pronoun subjects, such as *j(e)* in (17), reanalyze as agreement affixes in (18), a new topic/subject appears, such as *moi* (me) in (23).

(23) ***Moi*** *j'ai* *froid.* Spoken French
me 1SG.have cold
"I am cold."

Evidence of a renewal of the topic *moi* in (23) as subject is that, in spoken varieties, the topic DP is an indefinite or quantifier, as in (24) and (25), and these cannot be topics because they are new information and topics are old information. They are therefore seen as having been reanalyzed as subjects.

(24) *Chaque femme* *elle* *parle* Pied Noir French
Every woman 3SGF talks
"Every woman talks." (Roberge 1990: 97)

(25) *Un Cadien* *ça travaillait pas.* Acadian French
An Acadian 3 works not
"An Acadien doesn't work." (Girard 2010: 2010)

The change from topic in (23) to subject in (24) and (25) can be understood as an avoidance of indeterminate structures. For the language learner to choose the topic over the subject would mean choosing an indeterminate structure, as in (21b). Reanalyzing the topic as subject eliminates that.

In this section, I showed that topicalized subjects involve a derivation with two copies in the same domain. This is in violation of determinacy.

13.6 Conclusions

Historical linguistics benefits by the novel questions Chomskyan, generative grammar poses. Most recently, they have included, for instance, how do we avoid labeling paradoxes, as in Chomsky (2013; 2015) and determinacy violations, as in Chomsky, Ott, and Gallego (2017). In the past, there has been innovative work on changes in word order and information structure that wouldn't have been done if generative grammar hadn't provided the Phrase Structure Rules, Parameters, or Cartography of the clause (and the nominal). There is thus a lot of opportunity for historical linguistics to benefit from generative grammar.

Historical linguistics, in its turn, is most beneficial for generative grammar when it uncovers recurring patterns of change, such as the frequent grammaticalizations and cycles of change. Because written sources in English go back at least 1500 years, we can see these reanalyses recur. These then provide a window on the acquisition process, so crucial to generative grammar. If different varieties all change in the same direction (all renew in a similar way), there must be a universal force driving that, and that can be found in the Third Factors (e.g. Labeling, Determinacy, and Economy).

Endnotes

1 See, work by Closs (later Closs Traugott), King, Kiparsky, Klima, Lakoff, and Lightfoot (cf. van Gelderen 2011b, 2015, 2016 for an overview). Starting in 1990 in York, generative historical linguists have come together through the Diachronic Generative Syntax (DIGS) conference, which is devoted entirely to diachronic generative syntax. Many of the DiGS conferences had selected papers appear, e.g. as Battye and Roberts (1995), van Kemenade and Vincent (1997),

Pintzuk, Tsoulas, and Warner (2000), Crisma and Longobardi (2009), and Galves, Cyrino, Lopes, Sandalo, and Avelar (2012).

2 The situation is more complex as, e.g. Walkden (2016) shows.

References

Allen, C. 1977. *Topics in Diachronic English Syntax*. UMASS Dissertation.

Baker, M. 2008. *The Syntax of Agreement and Concord*. Cambridge: Cambridge University Press.

Battye, A., and Roberts, I, eds. 1995. *Clause Structure and Language Change*. Oxford: Oxford University Press.

Biberauer, T., and I. Roberts 2008. Cascading parameter changes. In *Grammatical Change and Linguistic Theory*, edited by T. Eythórsson , 79–113. Amsterdam: John Benjamins.

Canale, M. 1978. *Word Order Change in Old English*. McGill Dissertation.

Chomsky, N. 1965. *Aspects of the Theory of Syntax*. Cambridge: MIT Press.

Chomsky, N. 1981. *Lectures on Government and Binding*. Dordrecht: Foris.

Chomsky, N 2004. Beyond explanatory adequacy. In *Structures and Beyond,* edited by A. Belletti, 104–131. Oxford: Oxford University Press.

Chomsky, N. 2005. Three factors in language design. *Linguistic Inquiry* 36.1: 1–22.

Chomsky, N. 2007. Approaching UG from below. In *Interfaces + Recursion = Language*, edited by U. Sauerland and H-M. Gärtner 1–29. Berlin: Mouton de Gruyter.

Chomsky, N. 2013. Problems of Projection. *Lingua* 130: 33–49.

Chomsky, N. 2015. Problems of projection: Extensions. In *Structures, Strategies, and Beyond*, edited by E. Di Domenico C. Hamann, and S. Matteini, 3–16. Amsterdam: John Benjamins.

Chomsky, N. 2019. UCLA lecture. https://linguistics.ucla.edu/noam-chomsky/. Accessed April 25, 2020.

Chomsky, N., and M. Halle 1968. *The Sound Pattern of English*. Cambridge: MIT Press.

Chomsky, N., A. Gallego, and D. Ott 2017. Generative Grammar and the Faculty of Language: Insights, *Questions, and Challenges.*

Cinque, G. 1999. *Adverbs and Functional Heads*. Oxford: Oxford University Press.

COCA. The Corpus of Contemporary American English, a 520 million word corpus from between 1990–2015. http://www.americancorpus.org/

Crisma, P., and G. Longobardi, eds. 2009. *Historical Syntax and Linguistic Theory*. Oxford: Oxford University Press.

Eyþórrson, T. 1995. *Verbal Syntax in the Early Germanic Languages*. Cornell Dissertation.

Galves, C., S. Cyrino, R. Lopes, F. Sandalo, and J. Avelar, eds. 2012. *Parameter Theory and Linguistic Change*. Oxford: Oxford University Press.

Gelderen, E. van 1993. *The Rise of Functional Catergories*. Amsterdam: John Benjamins.

Gelderen, E. van 2011a. *The Linguistic Cycle*. Oxford: Oxford University Press.

Gelderen, E. van 2011b. Grammaticalization and generative grammar. In *The Oxford Handbook of Grammaticalization*, edited by H. Narogg and B. Heine, 43–55. Oxford: Oxford University Press.

Gelderen, E. van 2015. Formal Syntax and Language Change. In *Routledge Handbook of Historical Linguistics,* edited by C. Bowern and B. Evans, 326–342. London: Routledge.

Gelderen, E. van 2016. Generative frameworks and approaches. In *The Cambridge Handbook of English Historical Linguistics,* edited by M. Kytö and P. Pahta, 79–94. Cambridge: Cambridge University Press.

Gelderen, E. van 2018a. "Problems of Projection: The Role of Language Change in Labeling Paradoxes." *Studia Linguistica,* 72 (1): 113–127.

Gelderen, E. van 2018b. *Analyzing Syntax through Texts*. Edinburgh: Edinburgh University Press.

Gelderen, E. van 2019. Cyclical change and problems of projection. In *Cycles in Language Change,* edited by M. Bouzouita, A. Breitbarth, L. Danckaert, and E. Witzenhausen, 13–32. Oxford: Oxford University Press.

Girard, F. 2010. Le statut des clitiques sujets cadiens. https://www.linguistiquefrancaise.org/articles/cmlf/pdf/2010/01/cmlf2010_000209.pdf

Givón, T. 1979. *From discourse to syntax. Syntax and Semantics 12: 81–112*. New York: Academic Press.

Halle, M. 1962. *Phonology in Generative Grammar*. Chicago: Word.

Kemenade, A. van 1987. *Syntactic Case and Morphological Case in the History of English*. Dordrecht: Foris.

Kemenade, A. van, and N. Vincent, eds. 1997. *Parameters of Morphosyntactic Change*. Cambridge: Cambridge University Press.

Kiparsky, P. 1996. Indo-European Origins of Germanic Syntax. In *Clause Structure and Language Change,* edited by I. Roberts and A Battye, 140–167. Oxford: Oxford University Press.

Los, B. 2005. *The Rise of the To-Infinitive*. Oxford: Oxford University Press.

Maling, J. and A. Zaenen 1978. The Nonuniversality of a Surface Filter. *Linguistic Inquiry* 9 (3): 475–497.

Perlmutter, D. 1971. *Deep and Surface Structure Constraints in Syntax*. New York: Holt, Rinehart and Winston.

Philippi, J. 1997. The rise of the article in the Germanic languages. In *Parameters of Morphosyntactic Change*, edited by A. van Kemenade and N. Vincent, 62–93. Cambridge: Cambridge University Press.

Pintzuk, S. 1991. *Phrase Structures in Competition*. University of Pennsylvania Dissertation.

Pintzuk, S., and A. Taylor 2011. *The independence of information status effects and the syntactic change from OV to VO in the history of English and Icelandic. Talk DiGS 13*, University of Pennsylvania.

Pintzuk, S., G. Tsoulas, and A. Warner. 2000. Syntactic Change: Theory and Method. In *Diachronic Syntax,* edited by S. Pintzuk, G. Tsoulas, and A. Warner, 1–22. Oxford: Oxford University Press.

Richards, M. 2008. Two kinds of variation in a Minimalist system. In Varieties of Competition, edited by F. Heck, G. Müller, and J. Trommer, 133–162, University of Leipzig.

Rizzi, L. 1982. *Issues in Italian Syntax*. Dordrecht: Foris

Rizzi, L. 1997. The fine structure of the left periphery. In *Elements of Grammar,* edited by L. Haegeman, 281–337. Dordrecht: Kluwer.

Roberge, Y. 1990. *The Syntactic Recoverability of Null Arguments. Kingston*: McGill-Queen's University Press.

Roberts, I. 1993. *Verbs and Diachronic Syntax*. Dordrecht: Kluwer.

Roberts, I., and A. Roussou. 2003. *Syntactic Change*. Cambridge: Cambridge University Press.

Walkden, G. 2016. Null subjects in the Lindisfarne Gospels as evidence for syntactic variation in Old English. In *The Old English Gloss to the Lindisfarne Gospels: Language, Author and Context,* edited by J. Fernández Cuesta and S. Pons-Sanz, 239–256. Berlin: De Gruyter Mouton.

Warner, A. 1993. *English Auxiliaries: Structure and History*. Cambridge: Cambridge University Press.

14

Second Language Acquisition

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14.1 Introduction

Noam Chomsky's ideas and work on the human language faculty and how language is acquired opened new territory on which a whole new framework in non-native language acquisition was established: generative second language acquisition, or GenSLA (White 1989, 2003). Research in this framework has brought fruitful and lasting discoveries and is thriving today. GenSLA researchers work with the hypothesis that the human mind functions in a similar way in language acquisition generally speaking, no matter whether a first or second language is acquired. This hypothesis is being put to the test with interesting results. The Galilean Challenge as formulated in Chomsky (2017) refers to the creativity of language, the wonder of the human ability to produce an infinite number of utterances that have never been heard or seen before. This creativity is very much in evidence in human beings who speak a second or additional language. In fact, investigating Chomsky's principles and parameters within the GenSLA framework has brought additional and convincing evidence for the essential validity of Chomsky's original insights. In the last 50 years, GenSLA researchers have demonstrated that linguistic universals deeply rooted in language design such as structure dependence are observed by second language (L2) speakers no matter whether their native language exemplifies them. Inquiry into L2 parameters has been vigorous, and L2 findings have sometimes foreshadowed changes in linguistic theory. Current endeavors have focused on features as a better manifestation of linguistic variation and as a more nimble explanation of L2 development, as compared to parameters. The most important development in GenSLA in the last decades has been the realization that no explanation of the L2A process can be complete without considering parsing, mental lexicon access, and psycholinguistic concerns more generally – in other words, third-factor effects (Chomsky 2005). In this chapter, I endeavor to highlight Chomsky's lasting legacy embodied in the GenSLA framework.

Before we delve into more specific findings and their implications, it is worth pondering two crucial differences between child and adult language learners. The first

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difference is obviously age of acquisition, with all of the considerations underlying the Critical Period Hypothesis (Lenneberg 1967). I cannot do justice here to the extensive literature on the issue (but see Slabakova 2016, Chapter 4). The Critical Period debate has not been settled convincingly yet, since it interacts with the second difference between child and adult learners. This second difference is easy to overlook and underappreciate: Learners who start acquiring a second language in adolescence or adulthood are typically exposed to vastly smaller amounts of target language input, compared to children acquiring their mother tongue. It is often the case that their experience of the target language is in the classroom and in reduced communicative situations. And yet, there is a striking gap between the scarce, impoverished input and the linguistic knowledge that adult L2ers acquire. Just like in native first language acquisition (L1A), linguistic experience vastly underdetermines linguistic representations.

14.2 Poverty of the Stimulus and UG Parameters

GenSLA was initiated and developed in the 1980s, directly powered by the logical problem of language acquisition (Chomsky 1980), also known as Plato's problem, and comparisons with child language acquisition. Children have been shown to acquire many abstract grammatical properties that could not have emerged on the basis of input observation alone. If this rationale is determined to explain L1A, it is by no means straightforward that it would be valid for L2A. The well-known and often rehearsed differences between child and adult language learning (Bley-Vroman 1990) warrant a debate. In fact, generative scholars have disputed this issue for decades. One side of the debate is represented by scholars too numerous to list here (e.g. Schwartz and Sprouse 1996, a.o.) and surveyed in White (1989, 2003). This position maintains that L2ers also know more about the target L2 grammars, in the same way that children's native language competence is underrepresented by the comprehensible input surrounding them. These researchers argue that the complexity of the linguistic generalizations that learners attain is analogously underdetermined by their classroom or natural environments. L2ers show that their grammars, even if not nativelike, are constrained by innate linguistic knowledge, represented by Universal Grammar (UG). On the other hand, other scholars (Bley-Vroman 1990; Clahsen and Hong 1995; Hawkins and Chan 1997) have argued that UG fully constrains only L1A, while L2A relies on other learning mechanisms, possibly third-factor principles but also rote learning, imitation, etc.

While evidence on both sides of the debate exists, findings of knowledge underrepresented by the input are abundant. To mention one example, a group of studies investigating the Overt Pronoun Constraint (OPC) make the case for UG engagement convincingly. The OPC (Montalbetti 1984) is a syntactic principle of grammar postulating that in null subject languages (but only in those languages), quantified DP subjects (e.g. *no one*) and *wh*-subjects (e.g. *who*) cannot co-refer with an overt embedded subject. Avoiding the details of the linguistic analysis here, the examples in (1) from English and (2) from Spanish exemplify the issue. The answer to the question in (1) can be the embedded subject *he* as well as some other person from the discourse. This is also possible for the Spanish null subject in (2a) but not for the overt subject in (2b). *El* must refer to someone else in the discourse, but not the person being questioned with *quién*.

(1) Who$_i$ believes that **he$_{i/j}$** is better than everyone?

(2) a. ¿Quién$_i$ cree que **Ø$_{i/j}$** es mejor que todos?
Who believes that *pro* is better than everyone
b. ¿Quién$_i$ cree que **el$_{*i/j}$** es mejor que todos?
Who believes that he is better than everyone

Arguably, this really subtle distinction can be viewed as a *poverty of the stimulus* learning situation (see Crain and Thornton this volume for additional discussion), as it involves a negative constraint (lack of one interpretation). In addition, as Spanish has two grammatical ways of expressing the message in (1), that is (2a) and (2b), the learner has to acquire that only one of these options is missing an interpretation. Positive evidence for this distinction is not provided in the input to learners. Finally, if the restriction is ever taught in language classrooms, such instruction is not reliably available. It is clear that for a learner of Spanish (or Japanese, Portuguese, etc.) whose native language is English, the interpretive contrast has to come after she has acquired null subjects, but it has to come "for free" from UG. If successful acquisition is attested, this knowledge does not come from the native language, from the input, or from instruction; hence, it must come from UG. A number of studies (Kanno 1997; Perez-Leroux and Glass 1999; Gürel 2003; Rothman and Iverson 2007) have demonstrated that L2 learners of Japanese, Spanish, Turkish, and Portuguese are sensitive to this subtle restriction, recognizing that an interpretation that is possible in the L1 does not hold in the L2. In other words, the OPC is obeyed in the interlanguage grammar, as are other principles of UG. More generally speaking, GenSLA provides crucial evidence on what happens to linguistic representations under severely curtailed input conditions. If second language speakers are demonstrated to have knowledge underrepresented in the input, then the case for such knowledge being acquired as part of principles and parameters is strengthened indeed.

The null subject parameter (Chomsky 1981; Rizzi 1982; see also Sheehan this volume) was among the very first to be investigated extensively in GenSLA. Together with the null subject property itself, the parameter was originally proposed to cluster null expletive subjects (*it* in *It is raining*), free subject–verb inversion,[1] the *that*-trace effect,[2] and the OPC discussed above. Purportedly, learners had to acquire only one of the properties in the cluster – say, availability of referential null subjects – in order to access all the rest of the constructions.

The earliest L2A studies (White 1985; Hilles 1986; Phinney 1987) did not find evidence for the clustering of those properties. Neither the *that*-trace effect nor subject–verb inversion in declaratives was attested to be acquired at the time when learners already demonstrated knowledge of null subjects and null expletives (Liceras 1989; Isabelli 2004). Confirming the clustering of null subject knowledge and the OPC, Rothman and Iverson (2007) maintained that the null subject parameter cluster does not contain subject–verb inversion and the *that*-trace effect, as also argued by Jaeggli and Safir's (1989) theoretical reconsideration of Rizzi's (1982) proposal. In this case, L2A findings were in a position to disconfirm a parametric cluster that could not have been tested in L1A due to the different complexity of the properties. Between the ages of 2 and 3 1/2 (on average), when English-learning children produce null subjects (Hyams 1986), they cannot be tested on *that*-trace effects, for example, because this construction is outside of their linguistic repertoire. In sum, examining poverty of the

stimulus learning situations and parameter knowledge in second language learners has afforded new testing grounds and support for the theory of Universal Grammar.

14.3 Subjacency, the Empty Category Principle, and Structure Preservation

In addition to interpretation, poverty of the stimulus situations provide an opportunity to test UG-based knowledge of graded distinctions beyond simple acceptability. Martohardjono (1993) examined the acceptability of subjacency violations in *wh*-movement, (roughly the requirement for a *wh*-phrase not to jump over too many nodes in its movement to the left periphery of the sentence). The Subjacency Condition was probably the most studied principle of UG in the 1980s and 1990s (see Belikova & White, 2009 for a review). Martohardjono tested rejection rates of unacceptable sentences by native speakers of Indonesian and Chinese, languages without *wh*-movement, in which subjacency applies differently compared to English. She tested extractions of subjects and objects of relative clauses. These sentences look superficially similar, and the obvious analogy suggests they should be treated in a similar manner. However, linguistic theory had already identified that these two extractions differ in acceptability.

(3) ??Which car did John spread [$_{NP}$ the rumor [$_{CP}$ that the neighbor stole _____]]?
(4) *Which neighbor did John spread [$_{NP}$ the rumor [CP that _____ stole a car]]?

Sentences as in (3) violate subjacency, but do not lead to strong ungrammaticality: These are called weak violations. They should contrast in the reader's judgments with strongly unacceptable sentences as in (4), which violate subjacency and another linguistic principle, the Empty Category Principle. The latter requires certain empty categories, namely, traces of movement, to be properly licensed (governed). The concrete linguistic analyses assumed at the time are immaterial to the observation that differences in acceptability obtain for native speakers, who rejected the strong violations with 99% accuracy but the weak violations only 78% of the time. It is remarkable, then, that the same sensitivity to strong and weak violations was exemplified by the Indonesian (87% vs. 42%) and the Chinese native speakers (76% vs. 38%). If UG is not at work here, it is hard to imagine how these speakers of languages without *wh*-movement could have made this subtle distinction. Neither type of sentence appears in the input addressed to learners because they are unacceptable. Furthermore, in the strong violation in (4), the moved phrase jumps over fewer constituents compared to the more acceptable sentence in (3), so the former should have been easier to parse.

Structure dependence is another hallmark of UG-sanctioned linguistic behavior, one that is given frequently by Chomsky as an example of speakers being sensitive not to linear order but to structural positions. As exemplified in (5)–(7), only the main clause copula can be inverted with the subject, not the copula from within the relative clause, although it is linearly closer to the main subject (Chomsky 1980).

(5) The man [$_{RC}$ who is here] is tall.
(6) Is the man [$_{RC}$ who is here] ___ tall?
(7) *Is the man [$_{RC}$ who ___ here] is tall?

Structure dependence is directly demonstrated in languages with auxiliary verb movement to form questions. However, there are languages such as Arabic and Japanese that form the questions in (6) and (7) with the help of question particles, not movement. Cook (2003) set out to test whether speakers of languages with and without movement would be equally sensitive to unacceptable sentences as in (7). In a range of speakers from six different L1s, all language groups were sensitive to structure dependence with accuracy above 86%. At the same time, these participants had difficulty evaluating regular questions and relative clauses. The author concluded that all participants exhibited knowledge of this universal, even those that could not have transferred this knowledge from their native languages.

14.4 The Limits of the Input

In the previous sections, successful learning under poverty of the stimulus conditions was exhibited to argue that L2ers' knowledge of the target language is indeed constrained by universal principles that are not available from the native grammar. In this section, we will examine another type of argument, this time from partially successful acquisition. It is well established that linguistic experience does not generate linguistic representation in a direct manner. Some properties are amply modeled in the input but learners experience them as a challenge and error rates may be higher than accuracy rates. There are other, seemingly much more obscure and complex properties, whose acquisition is a snap. Why would that be?

According to the Borer–Chomsky conjecture as formulated by Baker (2008), "[a]ll parameters of variation are attributable to differences in the features of particular items (e.g. the functional heads) in the lexicon" (Borer 1984; Chomsky 1995). Thus functional morphology, hosting the features that regulate how a specific language grammar functions, is considered to be the locus of language variation. From the point of view of L2A, functional morphology has three essential aspects: (i) it has morphophonological form (a morpheme is pronounced either free or attached to another word as a prefix, suffix or infix); (ii) a morpheme carries grammatical meaning (e.g. tense, aspect, gender, case); and (iii) it has syntactic consequences by regulating which phrases move around in the sentence and which stay where they are merged. After learning the vocabulary items of the second language, the functional morphology is the single most important form–function mapping that learners have to master.

The features hosted in functional categories are frequently clustered, or bundled. Tense, the functional category richest in features, checks at least person, number, case, tense, and aspect features. A sentence such as (8) exhibits agreement with third-person singular nominative subject. Other feature values include present tense and habitual aspect. In addition, the functional category reflects the information that an overt subject in English is obligatory and that the verb does not move out of the VP – for example, to move to the other side of the adverb *often*.

(8) The woman often run-**s** in the park.

One could also consider the whole feature bundle from a modular perspective (Slabakova 2006). The functional category TP has three reflexes, as in (9).

(9) MORPHOPHONOLOGY: *–s*;
MEANING: present, habitual event;
SYNTACTIC INFORMATION: subject agreement, obligatory subject, nominative subject, verb in VP.

Now, it is conceivable that if second languages are learned by observing patterns in the input, as usage-based approaches to L2A would have it, lack of the first reflex, morphophonology, would point to lack of the other two reflexes, as the three should go together. There is no theoretical basis to separate the three types of knowledge within this approach. If a learner has not acquired the functional morphology to produce it consistently, she should also not know what this morphology refers to in terms of meaning, and what syntactic transformations it entails. The GenSLA prediction would be that the three types of knowledge may separate in development.

White (2003, 182–189) examined evidence for these predictions in the shape of learner morphophonological and syntactic knowledge tested in a number of production studies. She compared correct suppliance of morphophonological affixes (the first three columns in Table 14.1) with correctly supplied reflexes of syntactic knowledge (the last three columns). I will reproduce another comparison here, which keeps the native languages (Chinese) constant so as not to introduce more variables. Table 14.1 is modified from Slabakova (2016, p. 185). The data come from child and adult production of L2 English (Lardiere 1998a, b; Li 2012). Lardiere's subject, Patty, is a Hokkien and Mandarin-bilingual adult learner of English. Li's participants are six Mandarin-native children aged 7–9 acquiring English in a naturalistic environment in the USA. Patty's performance is considered to be at end-state, in the sense that she will not develop it further. The children's performance is captured longitudinally for eight months, starting when they had been in the USA for four months.

Table 14.1 highlights the largely similar pattern of accuracy between Patty, an advanced although end-state learner, and the child learners who are much less advanced. Second, while the suppliance of *-s* and *-ed* morphology ranges between 5% and 34%, suppletive forms (forms that are members of the same paradigm but not phonetically related, e.g. *be, are, is*) that bear the same features are supplied with over 90% accuracy. Finally and most importantly, there is a sharp distinction between accuracy on the functional morphemes and syntactic knowledge of the other features reflected in TP. On the basis of such evidence, White (2003) formulated the "syntax-before-morphology" argument, pointing to the separation of syntactic knowledge and morphophonological accuracy. I would like to underline that syntactic

Table 14.1 Correct functional morphology and syntactic features in obligatory contexts (% Accuracy)

	3 sg. agreement	Past tense on lexical verbs	Suppletive forms of *be*	Overt subjects	Nom. case	V in VP
Lardiere (1998a,b)	4.5	34.5	90	98	100	100
Li (2012)	16	25.5	93	100	100	–

knowledge seems to be at ceiling for all three properties (overt subject, nominative subject, lack of verb movement), and although this fact does not mean they appeared at the same time in the grammar of the learners, the observable facts do not contradict the claim of (near) simultaneous acquisition. What we can be sure of is that learners have acquired the syntactic knowledge fixed in TP.

The Feature Reassembly Hypothesis (Lardiere 2009) brought grammatical features reflected in functional categories to the front of GenSLA research. In a nutshell, difficulty is predicted where learners have to reassemble L1 functional features into new feature bundles in the new language. In addition, feature co-occurrence restrictions also compound difficulty (e.g. if a feature such as [plural] is always realized in the L1, but is only expressed in the context of [definiteness] in the L2). Recently, Lardiere (2017) expanded her explanation for difficulty in functional morphology production with the idea of feature hierarchies. Not only is the sheer number of features reflected in the affix context important; it is also crucial to consider that nodes and their features are arranged by the grammar in feature hierarchies (Harley and Ritter 2002). In order to illustrate this, we will look into third-person singular (sg) subject pronouns. The argument starts from the observation that many learners of English, including Patty mentioned above, often confuse the masculine and feminine forms of third-person sg pronouns. But it is not difficult to observe natural sex (female, male) in the environment and to connect it with pronouns like *she* and *he*. What is the source of the errors then?

> In Patty's case, one might consider that her (spoken) L1 Chinese fails to distinguish pronominal gender and therefore this would be a simple issue of L1 transfer; however, neither does her L1 distinguish pronominal case marking, which in her L2 English was perfect. In other words, while Patty often confused *him* or *his* with *her*, or *she* for *he*, she never confused *he* for *him* or *his*, or *she* for *her*. (Lardiere 2017, p. 56)

These are very specific, feature-related mistakes that are difficult to account for based on salience and frequency. Lardiere's (2017) explanation lies in a feature hierarchy where case (nominative, accusative, genitive) is higher than person/number features, themselves higher than gender (masculine, feminine). She argues that the more deeply embedded a feature is within a feature co-occurrence hierarchy, the less detectable it is and the more difficulty is expected in its retrieval.

To cross onto the meaning side now, does knowledge of the inflectional morphology related to TP in English bring forward its semantic reflexes? In particular, when learners are aware of the functional morphology, do they also know *all* of its meanings, taught and untaught? Slabakova (2003) investigated English L2 knowledge of various meanings associated with the functional categories Tense and Aspect. These meanings included the ongoing interpretation of the (present) progressive tense as in (10a), the habitual interpretation of the simple tense as in (10b), and the temporary state meaning of the progressive tense with stative verbs as in (10c).

(10) a. I am eating an apple.
b. I eat an apple every day.
c. I am being lazy today.
d. I saw Jake eat a cake. (completion is entailed)

The native Bulgarian of the learners does not have a progressive tense, so all of these meanings in (10a-c) would be rendered by the same verbal form, the present

tense. The study established that as soon as learners produced the TP morphology, they knew what it meant, that is, the distinction between (10a) and (10b). However, this is hardly surprising since these meanings are explicitly taught in language classrooms from the first days of classroom exposure, especially with dynamic verbs such as *eat*. The English learners in this study could have memorized instructed rules about temporal and aspectual interpretation. The meaning in (10c), a temporary state, even though much rarer in the input, was acquired as well. Finally, another and related meaning was tested in the experimental study: the complete event interpretation of bare verbs as in (10d). Embedded under a perception verb such as *see*, bare infinitives (in this case, *eat*) carry an entailment of completion. Jake must have eaten the whole cake to the end for this sentence to be true. This meaning is not taught in language classrooms, but learners were as accurate on it as they were on the other, instructed, meanings.

Taken together, the results discussed in this section point to a conclusion that once the functional categories are activated, all the attendant meanings are functional in the learner grammar. Under generative assumptions, but not usage-based assumptions, TP is a functional category where the affixes carry a number of bundled syntactic features and an array of temporal meanings. There is extensive evidence that even if they are not producing the functional morphology to criterion, learners have attained the semantic and syntactic knowledge pertaining to the category. GenSLA researchers have proposed the Missing Surface Inflection Hypothesis (Haznedar and Schwartz 1997; Prévost and White 2000) and the Feature Reassembly Hypothesis (Lardiere 2009) to explain such learning outcomes. The syntax-before-morphology view dovetails nicely with theoretical proposals such as Distributed Morphology (Halle and Marantz 1993) and exoskeletal approaches more generally (Borer 2003, see also discussion in Alexiadou and Lohndal, this volume). It is worth highlighting that explanations of this complex L2 behavior can only be based on an articulated, explanatory theory of language of the type Chomsky has offered us.

14.5 Conclusions

In this chapter, I have reviewed an array of facts and findings from the behavior of second language learners. In some cases, learners know more than is available to learn from the input; in other cases, they make errors where the input is abundant. Accounting for such elusive and abstract performance would be inconceivable without the explanatory power of Chomsky's generative linguistics. GenSLA is deeply rooted in the UG-based view of grammar and relies on it to delineate the hypothesis space of language learners.

At the same time, GenSLA has much to contribute to theory formation (Lohndal et al. 2019). The human capacity for learning language is evidenced unmistakably in the linguistic behavior of second language speakers, even though their language experience is likely curtailed, at least quantitatively. This state of affairs suggests that there are no *fundamental* differences between children and adults acquiring language. Therefore, generative linguistic theory should not neglect this rich source of acquisition data that the theory is called on to explain in the first place. Establishing a rich and specific knowledge of language in non-native speakers provides both strong support as well as a challenge for the theory itself.

Endnotes

1 Here is an example of subject–verb inversion, freely available in Spanish:
   (i) Ayer ganó Juan la lotería.
   yesterday won Juan the lottery
   "Yesterday Juan won the lottery."
2 When we ask a question about the subject of the subordinate clause, *that* must be absent:
   (i) *Who do you think **that** t_{who} kissed Mary?
   (ii) Who do you think t_{who} kissed Mary?

References

Baker, M. 2008. The macroparameter in a microparametric world. In *The Limits of Syntactic Variation,* edited by T. Biberauer, 351–373. Amsterdam: John Benjamins.

Bley-Vroman, R. 1990. The logical problem of foreign language learning. *Linguistic Analysis* 20: 3–49.

Borer, H. 1984. *Parametric Syntax: Case Studies in Semitic and Romance Languages*. Dordrecht: Foris.

Borer, H. 2003. Exo-skeletal vs. endo-skeletal explanations: Syntactic projections and the lexicon. In *The Nature of Explanation in Linguistic Theory,* edited by J. Moore and M. Polinsky, 31–65. Chicago: University of Chicago Press.

Chomsky, N. 1980. *Rules and Representations*. New York: Columbia University Press.

Chomsky, N. 1981. *Lectures on Government and Binding*. Dordrecht: Foris.

Chomsky, N. 1995. *The Minimalist Program*. Cambridge: MIT Press.

Chomsky, N. 2005. Three factors in language design. *Linguistic Inquiry* 36: 1–22.

Chomsky, N. 2017. The Galilean Challenge. *Inference* 3, 1. https://inference-review.com/article/the-galilean-challenge.

Clahsen, H., and U. Hong. 1995. Agreement and null subjects in German L2 development: New evidence from reaction-time experiments. *Second Language Research* 11: 57–87.

Cook, V. 2003. The poverty-of-the-stimulus argument and structure-dependency in L2 users of English. *IRAL* 41: 201–221.

Gürel, A. 2003. Is the overt pronoun constraint universal? Evidence from L2 Turkish. In *Proceedings of the 6th GASLA conference,* edited by J. M. Liceras et al., 130–139. Somerville, MA: Cascadilla Proceedings Project.

Halle, M., and A. Marantz. 1993. Distributed morphology and the pieces of inflection. In *The view from building 20*, edited by K. Hale and S. J. Keyser, 111–176. Cambridge: MIT Press.

Harley, H., and E. Ritter. 2002. Person and number in pronouns: A feature-geometric analysis. *Language* 78: 482–526.

Hawkins, R., and C. Chan. 1997. The partial availability of Universal Grammar in second language acquisition: The "failed functional features hypothesis." *Second Language Research* 13: 187–226.

Haznedar, B., and B. D. Schwartz. 1997. Are there optional infinitives in child L2 acquisition? In *Proceedings of BUCLD,* edited by Elizabeth Hughes, Mary Hughes and Annabel Greenhill, 257–268. Somerville, MA: Cascadilla Proceedings Project.

Hilles, S. 1986. Interlanguage and the pro-drop parameter. *Second Language Research* 2: 33–52.

Hyams, N. 1986. *Language Acquisition and the Theory of Parameters*. Dordrecht: Reidel.

Isabelli, C. 2004. The acquisition of the null subject parameter properties in SLA: Some effects of positive evidence in a naturalistic learning context. *Hispania* 87: 150–162.

Jaeggli, O., and K. Safir. 1989. The null-subject Parameter and Parametric theory. In *The Null-Subject Parameter, edited by Oswaldo Jaeggli and Ken Safir*, 1–44. Dordrecht: Kluwer Academic Publishers.

Kanno, K. 1997. The acquisition of null and overt pronominals in Japanese by English speakers. *Second Language Research* 13: 299–321.

Lardiere, D. 1998a. Case and tense in a "fossilized" steady state. *Second Language Research* 14: 1–26.

Lardiere, D. 1998b. Disassociating syntax from morphology in a divergent L2 End-state grammar. *Second Language Research* 14: 359–375.

Lardiere, D. 2009. Some thoughts on a contrastive analysis of features in second language acquisition. *Second Language Research* 25 (2): 173–227.

Lardiere, D. 2017. Detectability in feature reassembly. In *Salience in Second Language Acquisition,* edited by Susan M. Gass, Patti Spinner and Jennifer Behney, 41–63. New York: Routledge.

Lenneberg, E. H. 1967. *Biological Foundations of Language*. New York: Wiley.

Li, M.-C. 2012. The acquisition of tense and agreement by early child second language learners. *Unpublished PhD dissertation*, University of Illinois at Urbana-Champaign.

Liceras, J. 1989. On some properties of the "pro-drop" parameter: Looking for missing subjects in non- native Spanish. In *Linguistic Perspectives on Second Language Acquisition*, edited by Susan Gass and Jacqueline Schachter, 109–133. Cambridge: Cambridge University Press.

Lohndal, T., J. Rothman, T. Kupisch, and M. Westergaard. 2019. *Heritage language acquisition: What it reveals and why it is important for formal linguistic theories. Language and Linguistics Compass*, e12357, https://doi.org/10.1111/lnc3.12357.

Martohardjono, G. 1993. *Wh-Movement in the Acquisition of a Second Language: A Cross-Linguistic Study of Three Languages With and Without Movement. Unpublished PhD dissertation*, Cornell University.

Montalbetti, M. 1984. *After Binding: On the Interpretation of Pronouns. Unpublished PhD dissertation*, Cambridge: MIT Press.

Pérez-Leroux, A.-T., and W. Glass. 1999. Null anaphora in Spanish second language acquisition: Probabilistic versus generative approaches. *Second Language Research* 15: 220–249.

Phinney, M. 1987. The pro-drop parameter in second language acquisition. In *Parameter Setting,* edited by Tom Roeper and Edwin Williams, 221–246. Boston: Reidel.

Prévost, P. and L. White. 2000. Missing surface inflection or impairment in second language acquisition? Evidence from tense and agreement. *Second Language Research* 16: 103–134.

Rothman, J., and M. Iverson. 2007. On parameter clustering and resetting the null subject parameter in L2 Spanish: Implications and observations. *Hispania* 90: 328–341.

Schwartz, B. D., and R. Sprouse. 1996. L2 cognitive states and the full transfer/full access model. *Second Language Research* 12: 40–72.

Slabakova, R. 2016. *Second Language Acquisition*. Oxford: Oxford University Press.

Slabakova, R. 2003. Semantic evidence for functional categories in interlanguage grammars. *Second Language Research* 19: 42–75.

Slabakova, R. 2006. Is there a critical period for the acquisition of semantics? *Second Language Research* 22: 302–338.

White, L. 1985. The pro-drop parameter in adult second language acquisition. *Language Learning* 35, 47–62.

White, L. 1989. *Universal Grammar and Second Language Acquisition*. Amsterdam: John Benjamins.

White, Lydia. 2003. *Second Language Acquisition and Universal Grammar*. Cambridge: Cambridge University Press.

15

Multilingualism and Chomsky's Generative Grammar

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15.1 Introduction

It is not odd in science for an overarching theory to exist with relative neutrality to core concerns of subfields that (necessarily) draw from it. Take, for example, Einstein's general theory of relativity (henceforth, GTR), which endeavors to explain gravity as a consequence of the curvature of space–time resulting from the uneven distribution of mass. GTR explains why and precisely how what we experience as gravitational force on Earth occurs. Gravity is an essential core concept, if not variable, for countless fields outside of theoretical physics. Without understanding gravity, for example, human aviation, from planes to spacecrafts, could not exist. However, it would be imprecise – in the sense of being the intended *raison d'être* for the theory – to claim that GTR is about aviation *per se*. Indeed, GTR is foundational to countless exemplars of human ingenuity and scientific discoveries, but this does not entail a direct relationship for them to GTR as opposed to being subject to its implications.

Like GTR is concerned with explaining the basics of an observable experience – i.e., gravity – most people take for granted that Chomsky's theory of generative grammar (GG) is concerned with the basic nature of language. As an overarching theory of the mental construct of language with a capital "L," GG is not any more a theory about language acquisition than GTR is about aviation.

> … it is useful to keep in mind that generative grammar is the theory of the possible states attained. As such, generative grammar itself is neutral about how the final state (a grammar/I-language, or probability distribution over them) is attained. […] generative grammar is about the phenotype. (Rothman and Chomsky 2018, p. 765)

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GG envisions grammar as a system of mental representations that generate exactly those combinations, and only those, that form grammatical structures in any given language. As a result, GG remains impartial with respect to how acquisition unfolds in development or in its final state.

Does this mean that GG is *de facto* disinterested in language acquisition? Given the remit of this chapter and claims to contrary, it is important to establish why "no" is the only answer to such a question. Since at least the Principles and Parameters framework was proposed in the early 1980s (Chomsky 1981), there has been a virtual explosion of corollary acquisition theories/hypotheses/models. To date, thousands of empirical studies have been undertaken, seeking to either test GG's implicit claims for acquisition directly or use GG description/explanation to reverse engineer predictions and hypotheses regarding the developmental problem of acquisition in monolingualism and bi-multilingualism alike (see for reviews, Meisel 2011; Valian 2014; Hyams, Mateu, Ortfitelli, Putnam, Rothman, and Sánchez 2015). Although some claim that GG is not particularly interested in contributions from multilingual grammar and, by extension, not concerned with or relevant for the study of bi-/multilingualism, we maintain that such claims can only be sustained via misunderstandings. At first glance, quotes like the ones below play no small part in this belief:

> Why do chemists study H_2O and not the stuff you get out of the Charles River? You assume that **anything as complicated** as what is in the Charles River **will only be understandable**, if at all, on the basis of discovery of **the fundamental principles** that determine that nature of all matter, and those you have to learn about by studying pure cases. (Chomsky interview with Grosjean)

> [the language of a mixed community] … would not be "pure" in the **relevant sense**, because it would not represent a single set of choices among the options permitted by UG but rather would include "contradictory" choices for certain of these options. (Chomsky 1986, p. 17)

Failure to understand quotes such as those above in their proper context renders the Chomsky connection to multilingualism tangential, if not a bit tenuous. No one, least Chomsky himself, is ignorant of the fact that the idealized monolingual is an elusive, if existent, construct. Claiming that having the least amount of competing, difficult-to-disentangle variables as possible when trying to understand fundamental primitives of any given topic should be uncontroversial. It is this and only this that the above quotes intend to convey. Doing so is taken for granted in the physical sciences, and should have a similar place in social sciences, including linguistics. Key words we have bolded in the above quotes must be understood in their proper context, especially as regards the goals of GG. The question has never been whether evidence from multilingualism is important or potentially crucial to understanding the language-mind connection or whether GG can be useful in trying to understand how multilingualism unfolds, but rather, the extent to which having more than one grammar in a single mind might introduce variables that confound the process of understanding the essential components of language in the mind. Decades on from these quotes, in 2020, many generative scholars now maintain that variables introduced by multilinguals can often be meaningfully extricated and, better yet, capitalized on to understand more deeply *Language* in complement to the main goals of GG and its core questions (e.g. Polinsky

and Scontras 2019; Lohndal, Rothman, Kupisch, and Westergaard 2019; Rothman, González Alonso, and Puig-Mayenco 2019).

In the remainder of this chapter, space limitations being what they are, we highlight a mere subset of central constructs in GG, showing how they have featured prominently and thus shaped formal linguistic studies in multilingualism. In return, acquisition studies upholding these general tenets of GG have contributed in no small part to a more generalized documentation and understanding of how languages are acquired and processed across the lifespan. Because multilingualism includes a wide range of nonmonolingual populations, we divide these constructs across child bilingualism and adult third language (L3) for greater coverage (not least in light of Slabakova's (this volume) treatment of adult L2 acquisition). In the case of the former, we examine how *poverty of the stimulus* (Chomsky 1980, 1986) has been investigated. Using the nascent field of L3/L*n* acquisition as the backdrop, we discuss how the GG constructs of *I-language* versus *E-language* (Chomsky 1980, 1982) sit at the core of debates regarding the very notion of what *linguistic transfer* and *mental representations* should be taken to be. As these selected topics are mere exemplars chosen to highlight Chomskyan fingerprints in multilingualism research, the contextualization of each is limited to this purpose.

15.2 Bilingualism and Parameter Setting

Poverty of the stimulus (POS) – the proposed gap between what children are exposed to via *input* (inclusive of what could reasonably be deduced stochastically from it via domain-general cognitive mechanisms) and the eventually attained grammatical competence – provides a major argument in favor of a language-specific innate component. As suggested by Chomsky,

> the speed and precision of vocabulary acquisition leaves no real alternative to the conclusion that the child somehow has the concepts available before experience with language and is basically learning labels for concepts that are already a part of his or her conceptual apparatus. (Chomsky 1988, p. 28)

To us, data from early bilinguals, that is, individuals who were exposed to two or more languages during early childhood, provides even stronger arguments along the lines of the POS argument. Indeed, POS has been framed in different ways. As reviewed in Slabakova (Chapter 14, this volume), in the context of adult second language acquisition (or late bilingual acquisition), POS has featured more prominently as true *bankruptcy of the stimulus* (BOS) (e.g. Sprouse 2006). BOS would be properties for which there is absolutely no overt evidence in input that could reasonably result in apparent knowledge, for example, certain semantic entailments and/or keen knowledge of ungrammaticality of structures that are not *a priori* precluded on the basis of available positive evidence. However, POS has always included more than just the BOS subset, that is, all properties for which there is seemingly not sufficient, unambiguous positive evidence available, especially in light of age of mastery in children, to sustain claims of learning as opposed to triggering from a preexisting set of options enumerated as part of a linguistic endowment. How is it possible that children attain such complex knowledge within such a short period of time (e.g. Garfield 1994)? Input can be insufficient in its idiosyncrasies,

lack of explicit instruction, degeneracy in scope (input does not contain full information of grammatical rules), and quality (e.g. speech errors, non-native speech) (Pullum and Scholz 2002). The speed of acquisition and the extent of knowledge despite limited exposure, idiosyncrasies, and non-native input are especially remarkable in the context of early bilinguals, whose input space in each language is often much smaller compared to monolinguals. Whereas Slabakova (this volume) highlights BOS examples, a good choice given that adult L2ers are cognitive mature at the onset of L2 learning, we highlight here POS as it relates to complexity of the learning task and its early timing of acquisition, specifically by individuals who are not fully cognitively developed, namely young bilingual children.

Despite input being an important concept in the POS argument, generative studies, at least traditionally, tended not to study quantitative and qualitative aspects of the input systematically (see Rankin and Unsworth 2016 for discussion). More recently, a fair number of studies has been concerned with potential effects of input, comparing bilingual and monolingual children, or bilinguals to each other. The rationale behind comparing bilingual and monolingual children is that since bilinguals' time with language is divided over two languages, they should develop each individual language more slowly than monolinguals. Across bilinguals, those with comparatively less exposure should develop more slowly. Results on potential effects or noneffects of input are still inconclusive because the number of studies is limited and their conclusions are somewhat inconsistent. For example, Hoff, Core, Place, and Rumiche (2012) and Paradis (2011) found relationships between input (e.g. length and richness of exposure) and vocabulary and morphology, but Chondrogianni and Marinis (2011) found that while vocabulary and complex syntax (passives and *wh*-questions) were related to input, verbal morphology was not.

Numerous studies have shown that input affects the acquisition of gender assignment in bilingual children and adults (e.g. Unsworth 2013; Bianchi 2013; Kupisch, Akpinar, and Stoehr 2013). However, Unsworth (2014) convincingly demonstrates that the same children who show effects of input with gender marking do not show input effects with respect to direct object scrambling.

Interpretive constraints with scrambling in Dutch is an example of POS in the BOS-sense, because the information children need to acquire relevant meaning restrictions is entirely unavailable in the input. Unsworth (2014) shows that amount of exposure for the interaction of syntax with compositional semantics differences across bilingual children is irrelevant, arguably because this is something that is not acquired *per se* but indeed triggered even with minimal input. Her study calls for more research on domains where the role of input is unexpected or should be minimal, however, unlike the case of adult L2, such studies are not common in child bilingualism. Many other studies on child bilinguals, mostly focusing on syntax, however, show that reduced input does *not* result in decelerated acquisition and that bilingual children pattern with monolingual children without delays. In our view, this strengthens the POS argument: if monolingual language acquisition is not explainable given the (deficiencies of) input, then bilingual acquisition is so even less. We turn to focus on this below.

According to the *Autonomy Hypothesis*, bilingual children are capable of separating two grammatical systems without going through a temporary stage of (con)fusion (cf. Meisel's 1986, 1989). Moreover, early bilingual children pass through the same developmental stages as monolingual children and are capable of ultimately attaining grammatical competence in each of their languages, which does not differ in quality

from that of monolinguals. This is the case despite the extent to which both, either, or neither of these languages are supported in the larger society. In extreme cases, the quantity of exposure vis-à-vis monolinguals can be significantly more than halved. This fact widens the gap the POS argument highlights and Universal Grammar (UG) is purported to fill.[1] We provide three examples.

Meisel (1989) investigated word order in simultaneous learners of French and German. French word order is almost exclusively SVO, while German is a V2 language, which becomes visible with all nonsubject initial constructions. Objects and adverbials may be fronted in both German and French, but in French this results in the verb being in third position, while in German it triggers subject–verb inversion and leads to AdvVS or OVS structures. No later than with the appearance of two – or more – word utterances, the children consistently used different word orders in both languages, i.e., AdvVS or OVS structures in German but never in French. The V2 position in German is only motivated by the grammatical system. It does not serve stylistic purposes or express pragmatic functions. Therefore, such data are not only evidence that children are able to differentiate their two languages, but also that syntactic acquisition can be done with a minimal amount of input. As Meisel states:

> […] the fact that multilingual language development leads to multiple knowledge systems equivalent to those of monolinguals must be interpreted as strong evidence in support of the claim that the human language faculty predisposes the individual to become multilingual. Consequently, this fact should be taken into account in our thinking and theorizing about language and grammar. (Meisel 2001, p. 40)

Another example is constraints of verb movement in bilingual English-French children (Paradis and Genesee 1996). English and French differ in terms of verb syntax. In French, but not in English, finite verbs always move to INFL. The position of negation (Neg) is an indicator of whether movement has taken place, with verbs left of Neg being evidence for movement. Monolingual English and French children show crucial differences in their acquisition patterns.

(i) French children start to inflect verbs at the age of two years, while English children do so by the age of three years.
(ii) First appearances of Neg in French (*pas)* are found before non-finite verbs (e.g. *pas manger*), while finite verbs are placed after the negation particle (e.g. *mange pas*). In English, the negation particle always precedes the verb.
(iii) French has weak pronouns (i.e. the clitics *je, tu* …) and strong ones (i.e. the NPs *moi, toi* …). In French child speech the former co-occur with finite verbs, while the latter co-occur with finite and non-finite verbs. In English all pronouns are NPs and children use them with finite or nonfinite verbs.

The bilingual children studied by Paradis and Genesee (1996) acquired the properties of INFL earlier in French than in English, and in the same way as monolinguals, lending further support to the Autonomy Hypothesis. In discussing their results, the authors highlight the contrast between their own findings for syntactic acquisition and previous work on lexical acquisition. At a comparable age (1.6–3 years) bilingual children have a smaller vocabulary in each language compared to monolinguals. It is remarkable that bilingual children do not show a delay in their syntactic development although they (probably) receive less input than monolinguals in each language. Thus,

> there is no reliable relationship between an individual child's relative exposure to each language and […] patterns and rate of their grammatical development […] These findings concerning input are predictable on the assumption that syntactic acquisition is based on triggering and not learning. (Paradis and Genesee 1996, p. 20)

In later times, the Autonomy Hypothesis was relativized, conceding that bilingual children's two languages may influence each other (e.g. Müller and Hulk 2001). Yet, it has been shown numerous times – including in recent debates on heritage language acquisition outcomes (e.g. Kupisch and Rothman 2018) – that such influence does not lead to simplification. Despite cross-linguistic influence, the two target systems are not treated as if they were one. This is nicely illustrated by children acquiring two different article systems simultaneously (Kupisch 2007). Italian-learning children start to produce articles from a very early age in Italian, a language in which articles are obligatory in most syntactic contexts, but comparatively late in German, where the distribution of bare nouns and nouns preceded by articles depends on the mass count distinction and specific vs. generic reference (amongst other factors). Bilingual children can benefit from exposure to Italian in their acquisition of German, starting to use articles relatively early compared to monolingual German children. Rather than simply employing articles in contexts where they are licit in Italian but illicit in German, their use of articles is restricted to contexts where they are obligatory. Once more, the example can be taken as evidence for language separation and the idea that all children acquire syntactic generalizations based on comparatively little input, precisely because they start the process with a reduced hypothesis space. Bilingual children can bootstrap from the developing grammar of one of their languages to the development of the other, resulting occasionally in acceleration. Crucially, despite reduced input in one or both of the languages the cumulative effect of language exposure works in the bilingual's favor precisely because language is not learned (entirely) through experience.

The observation that grammatical acquisition differs from lexical learning, especially in multilinguals, continues to provide strong support for the view that the acquisition of grammar is aided by preexisting domain-specific knowledge; thus, it is substantially distinct from other types of learning.

15.3 Multilingualism and the I-language/E-language Debate

In this section, we shift to another GG construct, showing how it sits centerstage in the emerging field of formal linguistic approaches to adult third (L3) or more (L*n*) acquisition. Space does not permit an exhaustive contextualization of the L3/L*n* field, nor would it be necessary for the purpose of this chapter's remit (see Rothman, González Alonso, and Puig-Mayenco 2019 for review). Although not completely identical, GG essentially formalizes the *competence* vs. *performance* distinction with the terms *I-language* and *E-language*. *I-language* refers to internal language, that is, the mental representation of grammar in the mind or "some element of the mind of the person who knows the language, acquired by the learner, and used by the speaker-hearer" (Chomsky 1986, p. 22). Much like the construct of performance, *E-language*, or external language, encompasses all that affects the use of language in real time. *E-language* is, thus, "the observed use of language" (Chomsky 1965, p. 4), or the byproduct of the interaction of the *I-language* system with external factors such as context, extraneous

performance variables, memory capacity, and the like. *I-language* is envisaged as a mental object, and as such is the sole focus of study in GG. By contrast, *E-language* is an ecologically valid reality and studying its properties is of equal importance for specific questions. GG, being primarily concerned with the phenotype, is concerned with theorizing about and describing *I-language* mental representations in the mind.

> We thus make a fundamental distinction between *competence* (the speaker-hearer's knowledge of his language) and *performance* (the actual use of language in concrete situations). Only under the idealization set forth […] is performance a direct reflection of competence. In actual fact, it obviously could not directly reflect competence. (Chomsky 1965, p. 4)

Historically, the study of language acquisition from a GG perspective has sought to understand and tap (empirically) into *I-language* (Hyams 1986; Snyder 2007; de Villiers and Roeper 2011). However, acquisitionists must confront *E-language* differently than (some) formal theorist, by the very nature of the data at their disposal. No one denies that external variables and individual differences in cognitive factors (such as memory) affect the way in which speakers use language in the real world or perform linguistic tasks in the laboratory. Therefore, no one takes for granted that performances, even on sophisticated and controlled linguistic methodologies, index mental representations directly. That said, as generative acquisitionists, we strive (or should be striving) to provide predictive theories and adopt methodologies that not only stay faithful to the *I-language* vs. *E-language* distinction but also maximize the probabilities of tapping into *I-language*.

Referring back to the Charles River quote above, it might seem, at first glance, that the proverbial waters of true multilingualism – where three or more languages are involved in a single mind – are too murky for GG connections. However, the GG *I-language* vs. *E-language* distinction is crucial for work on *transfer* at the initial stages of additive multilingualism. González Alonso and Rothman (2017) and Rothman, González Alonso, and Puig-Mayenco (2019) argue for a key distinction between the constructs of *transfer* and *cross-linguistic influence,* which in many ways parallel the *I-language vs. E-language* distinction.[2] They maintain that *transfer* should be understood as a copy of a representation (i.e. *I-language*) from previously acquired languages (e.g. Schwartz and Sprouse 1994, 1996, 2013; White 2003) and kept separate as a construct from *cross-linguistic influence,* which would include all *E-language* variables leading to an in-the-moment bleeding over of one language into a given parse/performance such as contextual language activation, working memory, language dominance, frequency of use, etc. True *transfer* should show relative systematicity, whereas *cross-linguistic influence* should be significantly more variable and subject to context-dependency. Indeed, the study of *E-language* performance variables in multilingualism is a well-grounded, hot topic of considerable practical value. Why should it not be? That said, if there is value to maintaining a *transfer* versus *CLI* distinction whereby they roughly map onto *I-language* vs. *E-language* constructs, then it is also crucial that theories offer predictive validity and that studies adhere to methodological practices that, in principle, can distinguish them along the same lines. This is an important first step, especially from a GG understanding, as *transfer* relates to interlanguage representations, the building block for grammatical development in multilingualism, while *CLI* crosses over in performance with underlying representations only partially, at best, and are conditioned by *E-language* factors at any given moment.

In reference to the above, Rothman, González Alonso and Puig-Mayenco (2019) offer a systematic review of L3/L*n* morphosyntactic transfer studies. They maintain

that distinguishing *transfer* from *CLI* reliably is best done at the earliest possible moment in multilingual acquisition because it is at that time, when experience with the *Ln* to be acquired is least, that some *E-language* variables and other byproducts of multilingual development itself can be reduced or most meaningfully teased out. It is crucial to point out that, at present, many L3 researchers, even those from a GG background, have not systematically distinguished *transfer* from *CLI,* either because they do not agree that such a distinction is necessary or particularly valuable or because they had not previously considered the implications not doing so has for *I-language* versus *E-language* distinctions.

Whatever the case may be, out of the 92 experiments Rothman et al. reviewed – within 63 published papers – 50 of the experiments test speakers (54.34%) who have proficiency in the L3 higher than beginners, ranging from intermediate to highly advanced. This means that in this 54.34%, pinpointing the source of task performance and being assured that such relates to *I-language transfer*, as claimed, is compromised. As it relates to methodologies used in these 92 experiments, 35 (38.05%) studies make claims of *transfer* based primarily or exclusively on production data, rather than comprehension. While it is perfectly possible that what these experiments reveal is *transfer* in the sense that we distinguished above, it could just as well reflect either byproducts of the multilingual learning process – an L3 interlanguage representation that has developed without reflecting *transfer* itself – or the inability for a particular method to reliably tap underlying representation. With significant amounts of exposure past an *ab initio* state, time passed for consolidation and learning and/or increased *E-language* variables confounded by mode of testing, we are less confident that the source of knowledge at the level GG seeks to tap, *I-language*, can be meaningfully isolated (Puig-Mayenco and Rothman 2019).

While it is interesting and significant to expose, understand, and eventually predict patterns of *CLI* throughout multilingual development, timing is important to have the best chances of tapping *transfer* at an *I-language* level. This does not entail that anything observed resembling *I-language transfer* at later stages is not genuinely so; it is simply the case that the waters become too muddy to meaningfully maintain the distinction at hand. Related to Chomsky's influence to multilingualism, then, it seems evident to us that theories seeking to be compatible with GG tenets of understanding the mental processes of language in *I-language* terms, are well served by the *transfer* vs. *CLI* distinction and that there is value in investigating each separately.

15.4 Conclusion

As we hope to have highlighted above, the reach of GG and Chomsky's influence on the study of multilingualism have been profound. The theory of GG provides a framework through which principled hypotheses regarding multilingual acquisition follow and make testable predictions while simultaneously providing a means to account for the relative ease and success of what, on the surface, seems to be a formidable task. Acquiring more than one language in childhood or adulthood is constrained by the same narrowed hypothesis space true of child monolingualism. Differences in context, of course, conspire to make the paths and outcomes of multilingualism distinct, but this is a question of degree. The formal linguistic study of multilingualism has as much to

offer the theory of GG as it has derived from the existence of Chomsky's seminal ideas and theoretical legacy.

Endnotes

1 Hyams (1991) might have been the first to point out that input to bilingual children can represent 50% or less in each language of the input that monolinguals receive. This generalization is probably too coarse and may not hold for each of the two languages or for every individual child (see De Houwer (2014) for discussion). Nevertheless, it is uncontroversial that bilingual children receive less input compared to monolinguals, especially in their minority language.

2 Researchers from other traditions have also affirmed this distinction (e.g. Herdina and Jessner 2002; Paradis 2004; Paradis and Genesee 1996 for child bilingualism).

References

Bianchi, G. 2013. Gender in Italian–German *bilinguals*: A comparison with German L2 learners of Italian. *Bilingualism: Language and Cognition* 16 (3): 538–557. https://doi.org/10.1017/S1366728911000745.

Chomsky, N. 1965. *Aspects of the Theory of Syntax*. Cambridge: MIT Press.

Chomsky, N. 1980. *Rules and Representations*. Oxford: Blackwell.

Chomsky, N. 1981. *Lectures on Government and Binding*. Dordrecht: Foris.

Chomsky, N. 1982. *Some Concepts and Consequences of the Theory of Government and Binding*. Cambridge: MIT Press.

Chomsky, N. 1986. *Knowledge of Language: Its Nature, Origin, an Use*. New York: Praeger.

Chomsky, N. 1988. *Language and Problems of Knowledge: The Managua Lectures*. Cambridge: MIT Press.

Chondrogianni, V., and T. Marinis. 2011. Differential effects of internal and external factors on the development of vocabulary, tense morphology and morpho-syntax in successive bilingual children. *Linguistic Approaches to Bilingualism*, 1 (3): 318–345. https://doi.org/10.1075/lab.1.3.05cho

Garfield, J. L. 1994. Innateness. In *A Companion to the Philosophy of Mind*, edited by S. Guttenplan, 366–374. Cambridge, MA: Basil Blackwell.

González A. J., and J. Rothman. 2017. Coming of Age in L3 Initial Stages Transfer Models: Deriving Developmental Predictions and Looking towards the Future. *International Journal of Bilingualism*, 21 (6): 683–697. https://doi.org/10.1177/1367006916649265

Grosjean, F. 2019. *A Journey in Languages and Culture: The Life of a Bicultural Bilingual*. Oxford: Oxford University Press.

Herdina, P., and U. Jessner. 2002. *A Dynamic Model of Multilingualism: Perspectives of Change in Psycholinguistics*. Bristol, UK: Multilingual Matters.

Hoff, E., C. Core, S. Place, and R. Rumiche. 2012. Dual language exposure and early bilingual development. *Journal of Child Language*, 39: 1–27. https://doi.org/10.1017/S0305000910000759

Houwer, A. De. 2014. The Absolute Frequency of Maternal Input to Bilingual and Monolingual Children. In *Input and Experience in Bilingual Development*, edited by T. Grüter and J. Paradis, 37–58. Amsterdam: John Benjamins.

Hyams, N. 1986. *Language Acquisition and the Theory of Parameters*. Dordrecht: Reidel.

Hyams, N. 1991. Seven not-so-trivia of language acquisition. In *Point Counterpoint: Universal Grammar in the Second Language*, edited by L. Eubank, 71–88. Amsterdam: John Benjamins Publishing Company.

Hyams, N., V. Mateu, R. Ortfitelli, M. Putnam, J. Rothman, and L. Sánchez. 2015. Parameters in language acquisition and contact. In *Contemporary Handbook of Linguistic Parameters*, edited by A. Fábregas, J. Mateu, and M. Putnam, 353–373. London: Bloomsbury.

Kupisch, T. 2007. Determiners in bilingual German-Italian children: What they tell us about the relation between language influence and language dominance. *Bilingualism: Language and Cognition*, 10 (1): 57–78. https://doi.org/10.1017/S1366728906002823

Kupisch, T., and J. Rothman. 2018. Terminology matters! Why difference is not incompleteness and how early child bilinguals are heritage speakers. *International Journal of Bilingualism*, 22(5): 564–582. https://doi.org/10.1177/1367006916654355.

Kupisch, T., D. Akpinar, and A. Stoehr. 2013. Gender assignment and gender agreement in adult bilinguals and second language learners of French. *Linguistic Approaches to Bilingualism*, 3: 150–179. https://doi.org/10.1075/lab.3.2.02kup

Lohndal, T., J. Rothman, T. Kupisch, and M. Westergaard. 2019. Heritage language acquisition: What it reveals and why it is important for formal linguistic theories. *Language and Linguistics Compass*, 13(12): e12357 doi.org/10.1111/lnc3.12357

Meisel, J. 1986. Word order and case marking in early child language: evidence from simultaneous acquisition of two first languages: French and German. *Linguistics*, 24: 123–183. https://doi.org/10.1515/ling.1986.24.1.123

Meisel, J. 1989. Early differentiation of languages in bilingual children. In *Bilingualism across the Life Span. Aspects of Acquisition, Maturity and Loss*, edited by Kenneth Hyltenstam, and Lorraine Obler, 13–40. Cambridge: Cambridge University Press.

Meisel, J. 2001. The simultaneous acquisition of two first languages. Early differentiation and subsequent development of grammars. In *Trends in Bilingual Acquisition*, edited by J. Cenoz, and F. Genesee, 11–41. Amsterdam: John Benjamins.

Meisel, J. 2011. *First and Second Language Acquisition*. Cambridge, UK: Cambridge University Press.

Müller, N., and A. Hulk. 2001. Crosslinguistic Influence in bilingual language acquisition: Italian and French as recepient languages. *Bilingualism: Language and Cognition*, 4(1): 1–21. https://doi.org/10.1017/S1366728901000116

Paradis, J., and F. Genesee. 1996. Syntactic acquisition in bilingual children: autonomous or interdependent. *Studies in Second Language Acquisition*, 18: 1–25. https://doi.org/10.1017/S0272263100014662

Paradis, J. 2011. Individual differences in child English second language acquisition: Comparing child-internal and child-external factors. *Linguistic Approaches to Bilingualism*, 1: 213–237. https://doi.org/10.1075/lab.1.3.01par

Paradis, M. 2004. *A Neurolinguistic Theory of Bilingualism*. Amsterdam: John Benjamins.

Polinsky, M., and G. Scontras. 2019. Understanding heritage languages. *Bilingualism: Language and Cognition*, 23: 4–20. https://doi.org/10.1017/S1366728919000245

Puig-Mayenco, E., and J. Rothman. 2019. Low proficiency does not mean ab initio: A methodological footnote for linguistic transfer studies. *Language Acquisition*, doi.org/10.1080/10489223.2019.1677668

Pullum, G., and B. Scholz. 2002. Empirical assessment of stimulus poverty arguments. *The Linguistic Review*, 18 (1–2): 9–50.

Rankin, T., and S. Unsworth. 2016. Beyond poverty: Engaging with input in generative SLA. *Second Language Research* 34: 563–572. https://doi.org/10.1177/0267658316648732

Rothman, J., and N. Chomsky. 2018. Towards eliminating arbitrary stipulations related to parameters: Linguistic innateness and the variational model. *Linguistic Approaches to Bilingualism* 8 (6): 764–769. https://doi.org/https://doi.org/10.1075/lab.18075.rot.

Rothman, J., J. González Alonso, and E. Puig-Mayenco. 2019. *Third Language Acquisition and Linguistic Transfer*. Cambridge, UK: Cambridge University Press.

Schwartz, B., and R. Sprouse. 1994. Word order and nominative case in nonnative language acquisition: A longitudinal study of (L1 Turkish) German interlanguage. In *Language Acquisition Studies in Generative Grammar*, edited by T. Hoekstra, and B. Schwartz, 317–368. Amsterdam: John Benjamins.

Schwartz, B., and R. Sprouse. 1996. L2 cognitive states and the full transfer/full access model. *Second Language Research*, 12 (1): 40–72. https://doi.org/10.1177/026765839601200103.

Schwartz, B., and R. Sprouse. 2013. Generative approaches and the poverty of stimulus. In *The Cambridge Handbook of Second Language Acquisition*, edited by J. Herschensohn and M. Young-Scholten, 137–158. Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/CBO9781139051729.010.

Snyder, W. 2007. *Child Language: The Parametric Approach*. Oxford, UK: Oxford University Press.

Sprouse, R. 2006. Full transfer and relexification: Second language acquisition and Creole genesis. In *L2 Acquisition and Creole Genesis: Dialogues*, edited by C. Lefebvre, L. White, and C. Jourdan, 169–181. Amsterdam: John Benjamins.

Unsworth, S. 2013. Assessing the role of current and *cumulative* exposure in simultaneous bilingual acquisition: The case of Dutch gender. *Bilingualism: Language and Cognition*, 16: 86–110. https://doi.org/10.1017/S1366728912000284

Unsworth, S. 2014. Comparing the role of input in bilingual acquisition across domains. In *Input and experience in bilingual development,* edited by T. Grüter, and J. Paradis, 181–201. Amsterdam: John Benjamins.

Valian, V. 2014. Arguing about Innateness. *Journal of Child Language*, 41 (S1): 78–92. https://doi.org/10.1017/S0305000914000336.

De Villiers, J., and T. Roeper (ed.). 2011. *Handbook of Generative Approaches to Language Acquisition*. New York: Springer.

White, L. 2003. *Second Language Acquisition and Universal Grammar. Cambridge Textbooks in Linguistics*. Cambridge, UK: Cambridge University Press.

Part III

Comparisons with Other Frameworks

16

The View from Declarative Syntax[1]

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16.1 Introduction

Nonderivational grammatical frameworks that are information-based, or feature-based, first emerged in the later 1970s, and after a period of development, have largely remained without major modification since the late 1980s. I will focus here on the frameworks of Head-Driven Phrase Structure Grammar (HPSG; Pollard and Sag 1987, 1994, Sag et al. 2003) as it developed from Generalized Phrase Structure Grammar (GPSG; Gazdar et al., 1985), and Lexical-Functional Grammar (LFG; Bresnan 2001; Bresnan et al. 2016; Dalrymple 2001).

A declarative framework lacks a procedural component – there are no steps in a derivation – and, for any language, ultimately pairs a syntactic analysis with a string of words. In one sense, the goal of the grammatical frameworks just listed is what has always been one part of the enterprise of generative grammar: to provide an explicit and structured account of what is a well-formed expression (for simplicity in this chapter, I limit consideration to sentences) in a given language, for any language. In that sense, the goals of the frameworks above are shared at least with the Extended Standard theory model of transformational grammar in the 1970s, and Government-Binding (GB) theory in the 1980s; see Gazdar et al. (1985, pp. 1–6) for more discussion. Hence, these frameworks aim to account for a generative grammar in the sense outlined by Chomsky (1965, p. 9):

> No doubt, a reasonable model of language use will incorporate, as a basic component, the generative grammar that expresses the speaker-hearer's knowledge of the language; but this generative grammar does not, in itself, prescribe the character or functioning of a perceptual model or a model of speech production.

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Formally, a generative grammar is a nondeterministic random enumeration procedure interpreted as a set definition. A generative grammar consists of (i) a set of initially given strings available at the start, plus (ii) a set of operations for constructing new strings from strings that are antecedently available. A generative grammar defines a given language if and only if every sentence of the language, and only those, can be constructed from the initially given strings using the operations. (My thanks to Geoff Pullum for this characterization.)

Chomsky has proposed an evolving series of syntactic frameworks which have a procedural implementation of the formal notion of a generative grammar, starting with some 'atomic units' (one of the "non-negotiable" properties – see immediately below) and a set of operations to give new strings, as the terminal yield (Spellout in the Minimalist Program) of structures which the operations create. We have the practice in the field of referring to this metaphorically as a 'generative' procedure. Viewed against that practice, declarative frameworks are not generative, as they do not 'generate' anything in the sense of the preceding paragraph. Pullum (2013) refers to that kind of approach as *Generative-Enumerative Syntax* and differentiates it from *Model-Theoretic Syntax*: GPSG, HPSG, and LFG essentially fall in the latter category: they tell you if a given string meets the constraints of the language, or not. This constitutes their approach to the challenge of defining the speaker-hearer's knowledge of a language, as in the Chomsky quote above.

Two further quotes from Chomsky and colleagues serve to illustrate the context with respect to which declarative frameworks can be understood. Chomsky et al. (2019, pp. 231–232) highlight the combinatoric potential of syntax, and what Chomsky has come to call "displacement":

> We consider two empirical properties non-negotiable … [the first being] … Atomic units – lexical items, whose basic nature remains a subject of debate – are assembled into syntactic objects, and such objects can occupy more than one position within a larger structure.

They illustrate displacement with an active/passive alternation:

(1) a. The teacher scolded John.
    b. John was scolded by the teacher.

… and continue:

> On the assumption that thematic relations are established in a strictly local fashion – a guiding idea of GG since its inception –, this entails that the nominal is displaced from its original position … To account for these elementary properties, any theory of GG must assume the existence of a computational system that constructs hierarchically structured expressions with displacement. … The latter notion [displacement] is non-negotiable in its abstract sense: there can be multiple determinants of interpretation for some syntactic object. The mechanisms implementing this basic fact vary across theoretical frameworks, of course.

The understanding of displacement follows from certain assumptions about Merge. Chomsky (2007, pp. 10–11) states the current position thus:

> It also follows that it was a mistake – mine in particular – to suppose that displacement is an "imperfection" of language that has to be assigned to UG or somehow explained in terms of

> its special functions. On the contrary, its absence would have to be accounted for by a UG stipulation barring I[nternal] M[erge]. It therefore follows that some form of transformational grammar – by now a radically stripped-down version of early proposals – essentially "comes free." If some other device is developed to account for the empirical phenomena of displacement and associated interpretations, it will require a stipulation barring IM and further stipulation of the additional mechanisms, therefore facing a considerable empirical burden.

Picking up on these ideas, I show some key properties that declarative frameworks assign to the atomic units – lexical items – below, and discuss the motivation behind this. The other non-negotiable property, displacement, actually involves a given syntactic unit having different kinds of property (e.g. in passive, a phrase being a subject while also being an object at the relevant level of abstraction). This is analyzed in declarative frameworks through different dimensions of the analysis, rather than through different stages in a derivation. Declarative frameworks cannot countenance movement, so no "stipulation barring IM" is necessary, or even expressible; they offer a different perspective on how syntactic relationships are represented.

In this chapter I survey some key aspects of declarative frameworks, and the motivation for them. In section 16.2 I consider how declarative frameworks instantiate a view of Generative Grammar directly inspired by Chomsky's early work, but without the procedural component. In section 16.3 I present some of the core design features which motivate declarative frameworks, and in section 16.4 I explore how syntactic phenomena are factorized and formalized in declarative frameworks, with a view to comparison with MP analyses.

16.2 Factoring Apart Structure and Information

16.2.1 The Legacy of EST: A Core Set of Generalizations

Many of the major factual generalizations that syntactic theory should account for were discovered between the 1950s and the 1980s. The initial transformational framework was highly successful in generating a huge body of facts and linguistic insights that most syntactic frameworks aim to account for. Every sentence had an analysis involving an initial phrase structure (PS) representation generated by phrase structure rules (PS-rules), followed by a sequence of later representations that were transforms of the original structure.

16.2.1.1 Structures and Operations

The PS representations and transformational operations on them were instrumental in characterizing constituency, asymmetric structural relations, and relatedness of different surface forms. In the first period of generative grammar, the formalization into structures and operations on them developed as a way to understand and represent grammatical competence.

The PS representations themselves came under scrutiny following the original ideas for X′-theory (Chomsky 1970): the idea that different categories could participate in configurationally similar structures. The base component of a standard transformational model had no place for even the simplest descriptions like "head-initial" or "head-final" or the notions of complement or specifier.

The transformational component came to be understood to be problematic in different ways, but I focus on two here. First, the Structure Preservation Hypothesis (SPH) of Emonds (1976) was based on the observation that transformationally derived structures in a given language have the same hierachical and configurational character as base structures generated by PS-rules.

Second, the ordered and cyclic application of transformations suggested the Derivational Theory of Complexity (DTC; Miller and Chomsky, 1963), which led to the expectation of psychological evidence for greater complexity in sentences whose syntactic analysis involved an internally complex derivation. However, the balance of psycholinguistic evidence failed to support the DTC: for instance, even though passive sentences were formally derived from actives, and therefore were given a more complex syntactic analysis, there is no evidence that passives are harder to process, or slower to be processed, relative to actives.

The declarative frameworks discussed here developed in part as reactions to the failure of the DTC, and certainly to the potential for overgeneration of the transformational framework (e.g., finding a way to constrain the transformational complement to one that respects the SPH). At the same time, Chomsky's GB theory (Chomsky, 1981) was developed for essentially the same reasons. Likewise, in all of the approaches, now-familiar components of X′-theory were incorporated in the early 1980s. The most salient components are: the notions of head, complement, and specifier; the idea of adjunction as creating a "like" category; and feature sharing between the head and its projections, up to the maximal projection.

16.2.1.2 Rules and Representations

Hornstein (2018, p. 55) presents a list of structural properties that syntacticians might agree are determined by the "Faculty of Language," properties which correspond to what he has called the "mid-level generalizations" of grammar; see also D'Alessandro (2019, p. 8) for a summary. For instance, we want to be able to account for data such as Chomsky (1973, p. 261), which we would relate to properties of verbs as being raising or control predicates, and binding conditions on anaphors and pronouns:

(2) a. They appeared to John to like each other.
    b. *They appealed to John to like each other.
(3) a. *We appeared to John to like us.
    b. We appealed to John to like us.

As syntactic frameworks have developed since the 1980s, they have diverged as to whether the focus is on constraints stated on representations, or on steps in a procedural derivation. GB theory has a mix of properties: conditions on rule application and conditions on representations. For instance, the examples above involve *appear* as a raising predicate which requires an operation of the rule Move-α, while *appeal* is a control predicate which requires a representational check involving a PRO subject. More recently, the "movement theory of Control" eliminates the representational condition on the empty category subject in favor of a derivational analysis similar in the relevant ways to the one for the raising predicate. (See Alexiadou and Lohndal (Chapter 3, this volume) for a summary of some the main aspects of GB.)

The GB theory Principles A and B were originally stated as a condition on a representation. For instance, Principle A looks for a specific relationship of coindexing

between antecedent and anaphor within a certain domain; taken as a condition on rule application, the principle must involve an operation of movement up to (near) the antecedent, within a certain domain.

In the development of the Minimalist Program (MP), Chomsky took the view that as some aspects of the grammar are procedural, and so require conditions on rule application, parsimony would dictate that all grammatical conditions are of that type, with no conditions on representation. Hence, the levels of GB over which representational conditions were stated were eliminated. The Minimalist Program is an attempt to deconstruct GB along purely procedural aspects (see e.g. Hornstein, 2018, p. 54) – in the limit, there is no "stopping off" at any point to evaluate a representation. In fact, though, each step in a derivation must involve a local representation – but one within which or to which some further operation must take place. The proposed operation of "Minimal Search" (Chomsky, 2007, p. 9) must inspect a structure to find something within it, and the outcome of that will constrain what (procedurally) can happen next.

Declarative frameworks have different dimensions of analysis – described immediately below – but not different levels in the sense that GB had (e.g. D-structure, S-structure). As there are no rules or operations, there are no conditions on rules, and so all conditions are stated over representations, as constraints.

16.2.2 Dimensions of Analysis

The legacy of the early transformational period as it is relevant for declarative frameworks can be summarized as in (4):

(4) a. the overt part of syntax is represented in a phrase structure tree
b. all information in syntax is structured
c. different parts of a syntactic representation may share information

As GB has developed into MP, it has been assumed that (4b-c) refer to the same structure as (4a): that only the structures of phrase structure represent syntactic information, and that relationships are expressed in that structure, derivationally. Hence, grammatical generalizations might be stated as constraints on rules or constraints on derivations; the ideal of the MP is that those constraints are inherent to the underlying system itself.

As described above, the same generalizations are stated in declarative frameworks as constraints on representations or constraints on relationships. These frameworks hold that all syntactic information is structured, but also that not all syntactic information is structure; and so they address the three parts of (4) by having three aspects to the overall representation:

(5) a. overt phrase structure
b. a clause-level representation of the information it conveys
c. an argument-structure representation for predicate-argument structure

All syntactic frameworks have a means to represent argument structure, and for any given predicate, its argument structure is structured according to the Thematic Hierarchy (e.g. Jackendoff, 1972) or something equivalent. The idea that syntax involves "displacement" only follows if the representation of argument structure is phrase-structural (as vP in the Minimalist Program). For declarative frameworks,

there is a mapping relation between argument structure and the surface grammatical properties, which is part of (5b). These properties include the LFG grammatical functions such as SUBJ and OBJ, or the list(s) of valence in HPSG, such as SUBJ and COMPS. (These same properties are characterized in the MP by the particular Agree relations between v and Obj and between T and Subj.) There is also a hierarchy at this level: a hierarchy of grammatical functions in LFG or a notion of increasing obliqueness on a valence list in HPSG. These hierarchies are the basis for the statement of f(unctional)-command in LFG or o(bliqueness)-command in HPSG for those syntactic phenomena that are sensitive to command relations. Broadly speaking, the "subjecthood" properties identified by Keenan (1976) divide into those which properly refer to argument structure, and those that refer to clausal grammatical information (Manning 1996), and different syntactic phenomena may relate to either representation. For instance, anaphor binding is determined by the argument structure hierarchy in some languages (e.g. Schachter, 1976 on Tagalog; Wechsler and Arka 1998 on Balinese).

The representation of clausal grammatical information (5b) includes a predicate, its arguments, adjuncts, and inflectional information of the familiar sort: Tense and Aspect for verbs, case and agreement features for NPs, etc. It is located in the SYN or SYNSEM of HPSG, or in f-structure in LFG (see (18) below). It is not part of the phrase structure representation (5a), but rather is the information that the overt structure conveys. This clausal representation is nevertheless structured in the sense that the information it contains is organized and grouped, residing logically where it belongs. This is somewhat different to the approach to clausal information in the MP, where information may start out quite distributed throughout the overall derivation, but is aggregrated through successive movements, but also destructively modified (e.g. a feature specification being used to drive one operation, then being deleted subsequent to the application of that operation).

The representations of argument structure and of clausal information are largely language-invariant, though the mapping between them shows more variation, as do the ways in which different syntactic phenomena that refer to them. The information that they represent is carried by the overt phrase structures, (5a), which are of course subject to the most variation, and therefore the least revealing about "deep" properties of language.

16.3 Design Features of a Grammatical Framework

Before getting to some salient properties of declarative frameworks, I will consider what constitutes motivation for a particular kind of syntactic analysis, framing the matter in terms of Chomsky's well-known three "levels of adequacy" (Chomsky 1964).

16.3.1 Levels of Adequacy

Chomsky set the agenda for generative grammar in terms of successive levels of adequacy. A generative grammar that defines a set of strings – as in the original conception, see section 16.1 – meets the criterion that he labeled "Observational Adequacy." However, this does not go far enough to include what is possibly his most significant contribution to linguistic theory, namely the demonstration that linguistic knowledge involves knowledge of structure, or of structured representations. The following quote

outlines what has been the agenda for syntactic theory, at least since the 1960s, and what is the common background against which the different frameworks here can be compared and contrasted.

> To summarize briefly, there are two respects in which one can speak of "justifying a generative grammar." On one level (that of descriptive adequacy), the grammar is justified to the extent that it correctly describes its object, namely the linguistic intuition – the tacit competence – of the native speaker. In this sense, the grammar is justified on external grounds, on grounds of correspondence to linguistic fact. On a much deeper and hence much more rarely attainable level (that of explanatory adequacy), a grammar is justified to the extent that it is a principled descriptively adequate system, in that the linguistic theory with which it is associated selects this grammar over others, given primary linguistic data with which all are compatible. In this sense, the grammar is justified on internal grounds, on grounds of its relation to a linguistic theory that constitutes an explanatory hypothesis about the form of language as such. (Chomsky 1965, pp. 26–27)

Since the GB era, Chomsky has taken explanatory adequacy to be the focus of syntactic theorizing (Rizzi 2016a; D'Alessandro 2019). This presupposes that there is a core of facts and generalizations (the "mid-level generalizations" noted above) so that there is a stable set of grammars that satisfy descriptive adequacy.

In this subsection I discuss how declarative frameworks have not followed the traditional lines of argument around explanatory adequacy, looking more to establish strong candidate frameworks that satisfy descriptive adequacy, and that can be part of broader cognitive or computational approaches to human language. In this sense, declarative frameworks committed 40 years ago to what has become known as Chomsky's "third factor" (Chomsky 2005, p. 6) for explaining the format of grammatical knowledge. The following quote outlines Chomsky's more recent view of the different components that enter into language acquisition:

(6) … we should, therefore, be seeking three factors that enter into the growth of language in the individual:
1. Genetic endowment, apparently nearly uniform for the species, which interprets part of the environment as linguistic experience, …
2. Experience, which leads to variation, within a fairly narrow range, …
3. Principles not specific to the faculty of language …
   - principles of data analysis that might be used in language acquisition
   - principles of structural architecture
   - principles of efficient computation

The first factor covers what was subsumed under the notion of Universal Grammar in earlier periods of generative grammar. Over the last 25 years, the trend in the development of the MP has been to reduce reliance on this purely innate component of grammar, in favor of the third factor (see also Alexiadou and Lohndal (this volume)). The reference in that factor to principles of data analysis and of structural architecture is quite salient as these are the principles at the basis of the considerations which I raise in the next subsection. As O'Grady (2012, p. 498) comments: " … the shift of focus to third-factor effects in generative grammar marks a milestone of sorts. Not because the idea is new, for it is not. Broadly speaking, the rest of the field has been committed to the primacy of third-factor explanations for decades."

Much of what has been asserted to be "explained" about explanatory adequacy is entirely theory-internal to transformational approaches, and receives a different account in declarative frameworks. A familiar example has been recently rehearsed in an overview paper (Chomsky et al. 2019, p. 233):

> The argument then and now is that the language-learning child never entertains the hypothesis that yes/no questions are formed by moving the linearly first auxiliary in the clause – a hypothesis that would receive ample support from cases such as (3) and requires complex examples of the kind in (4) to be refuted.
>
> (3) Is the tall man from Italy _ happy?
> (4) Is the tall man [who is from Italy] _ happy?

From the first inceptions of GPSG and LFG in the late 1970s, no issue could ever arise as to "which" auxiliary would take alternative positions after or before the subject, as the problem necessarily reduces to different positionings of the same head. As noted by Pullum and Scholtz (2002, p. 41), an example as simple as *Can I have it?* is essentially enough to determine the only correct syntactic analysis. Apart from the difference in sentence-type between declarative and interrogative, which the child must be able to comprehend, *Can I have it* and *I can have it* express the same grammatical and propositional content. From a declarative perspective, the hypothesis space is then (only) one that involves alternate overt realizations (different strings) of the same abstract content. (See the discussion of (16) and (19) below; and for a more detailed exposition, see Müller 2016, pp. 470–487.)

16.3.2 Syntactic Structures and Syntactic Properties

Declarative frameworks offer a different perspective on explanatory adequacy. I will illustrate here with two simple cases.

First, the French example in (7) motivates both the lexicalist hypothesis and the notion that agreement is not directional.

(7) Je suis heureuse.
I am happy.FEM.SG
"I am happy." (spoken by a female)

Neither the subject pronoun *je* nor the inflected verb *suis* are categorized or marked for gender – as in English and many other languages – yet the predicate adjective is marked as feminine (and singular). The non-formal linguistic intuition that the adjective agrees with its subject, or "agrees with a noun," has been the basis of many formalized linguistic analyses: the predicate adjective is a target and the subject should be its controller. Yet there is no plausible source in the lexical content of (7) for a feminine gender specification except for the adjective. It is certainly true of the *sentence* (7) that it expresses a meaning involving a feminine subject, but the morphosyntactic basis of that meaning could not be *je* or *suis*, under any plausible analysis of those words.

This example is very powerful. From it, it follows then that *heureuse* is a lexical item marked for feminine gender independently of the syntactic structure in which it appears, as there is no source for feminine in the rest of the structure. This entails the Lexicalist

hypothesis, as each X^0 in the syntactic structure has properties that do not refer to any other X^0 in the structure – often referred to as "Lexical Integrity" (e.g., Bresnan 2001, p. 92; Bresnan et al. 2016, p. 92).

Second, it follows that "agreement" is the name we give to a situation in which two or more syntactic elements put constraints on a single informational unit, but that there is no priority of one element over the other(s). In (7), all three such elements (the words, in this case) put constraints on what the subject is; and as the combination of those constraints is not contradictory, so the example is well-formed.

(8) a. *je*: a first person singular pronoun, used as a subject
b. *suis*: a verb whose subject is first person singular; whose subject is (informationally) the same as its predicate complement's subject
c. *heureuse*: an adjective whose subject is feminine and singular

Local syntactic relationships are typically located in a predicate – these will involve what kind of arguments the predicate takes, possibly specifications of case, whether it is a raising or control predicate, agreement information, and so on. The apparent directionality of agreement has nothing to do with "agreement" itself – as a mechanism of agreement does not exist – but rather, comes from the second property of *suis*, that it is effectively a raising predicate, and so whatever is true of its subject is true of its complement's subject.

With regards to the implications for explanatory adequacy, this simple example shows that the format of grammars is only consistent with those that lack derivation and directionality – in other words, if the hypothesis space is restricted to declaratively stated grammars, we expect that languages will show examples like (7).

Second, (9) (originally from Hudson, 1977; see also Gazdar et al. 1985, p. 64; Bresnan 2001, p. 19, Bresnan et al. 2016, p. 14), illustrates one of "paradoxes of movement":

(9) a. *I aren't happy.
b. Aren't I happy?

An initial positioning of an internally negated auxiliary is taken as evidence in movement analyses that the auxiliary has undergone several movements, combining with Neg and then with T[ense] before moving to C. However, from the notional analytic source *I am not happy* there is no pre-T-to-C version **I amn't happy*, as in (standard) English there is no form *amn't*, and (9a) is also ungrammatical. In this use, then, the form *aren't* is a word that can only appear in the C, or inverted-aux, position, but not in any other position. In terms familiar from the early days of transformational grammar, (9b) would have to be analyzed as a grammatical example derived from an ungrammatical source.

The contrast in (9) shows that the syntactic properties that an item has (being a tensed negated auxiliary in this case) are not inexorably associated with structural derivations that aggregate information. A movement-based account of (9) would have to assume that the syntactic features of *aren't* can be assembled on T, and from there moved to C, but that there is no lexical item that can spell out those features on T, but only on C. In other words, what actually matters is the surface position of the realization of a set of syntactic properties, not where (or where else) those properties came from.

This is exactly what a declarative framework provides, with the same implication for explanatory adequacy – if an element in a higher position must correspond to a derivationally related version of itself in a lower position, pairs like (9) should not exist. But they do exist, and they show that the format of grammars should (only) recognize that words have bundles of features that are associated with (sets of) syntactic positions.

16.4 Salient Properties

In this section I outline a few of the key properties of declarative frameworks. I further observe that these frameworks already have several aspects of representation which have been adopted later on by MP.

16.4.1 Lexicalist

Declarative frameworks are lexicalist, built on the assumption that the (only) terminals in the phrase structure are word-level entities, the X^0s of X′-theory. For simplicity, I will refer to each one as a "word." A word may be internally complex, carrying the same kinds of information as may be expressed by other elements or configurations in the syntax, but formed in a given language according to its constraints on morphology, not on syntax.

The following Swedish example from Müller and Wechsler (2014, p. 29) illustrates several properties that motivate the lexical-based analysis. It involves coordination of an active and a passive verb:

(10) Golfklubben begärde och beviljade-s marklov för banbygget efter en hel
golf.club.DEF requested and granted-PASS ground.permit for track.build.DEF after a whole
del förhandlingar och kompromisser med Länsstyrelsen och
part negotiations and compromises with county.board.DEF and
Naturvårdsverket.
nature.protection.agency.DEF
"The golf club requested and was granted a ground permit for track construction after a lot of negotiations and compromises with the County Board and the Environmental Protection Agency."

Müller and Wechsler argue that this example does not involve Right-Node Raising, but rather coordination of two finite verbs at the X^0-level (*begärde och beviljades*). Each verb is a syntactic word, marked for past tense (the *-de* part), and the second one is marked for passive (the *-s*). Hence the voice alternation active/passive is represented on single words and does not involve spans of structure involving separate heads such as V, v, and Voice. Additionally, the second verb is a straightforward counterexample to the "Mirror Principle" (Baker, 1985), which is supposed to diagnose a close relationship between syntactic structure and word-internal morpheme structure. Swedish passive *-s* always appears external to other tense or aspectual suffixes on the word, even though in an expanded MP-style clausal structure the Voice head would be taken to be lower and therefore internal with respect to Aspect or Tense heads.

Declarative frameworks therefore adopt the Lexicalist Hypothesis of Chomsky (1970). Chomsky argued that the shared properties of different words based on the

same lexeme could be accounted for without recourse to transformation (a nominalization transformation for the specific examples considered in that paper), and he introduced X′-theory to account for structural similarities across categories. Declarative frameworks expand on this perspective, using other syntactic information not directly represented in the phrase structure (cf. (5)) to capture the appropriate similarities.

16.4.2 Features

With a focus on representation, rather than on procedure, it is necessary for declarative frameworks to have a clear and consistent format for representation.

16.4.2.1 The Representation of Grammatical Information

LFG and HPSG are built on the foundation that featural specifications in morpho-syntax are of the form [attribute: value], and that well-formedness requires every attribute in a given representation to have an appropriate value. The attribute-value format is used in LFG to represent functional structure, which represents the relational and featural content of a clause, but not constituent structure or argument structure, and which is deliberately designed to not look like a phrase structure, to signify that it represents a different kind of syntactic information.

GPSG adopted an approach to PS-rules based on the familiar two-level X′-theory (e.g. Gazdar 1982, p. 136), and after it developed the earliest Head Feature Convention (e.g. Gazdar 1982, p. 135), it then applied the idea of feature-matching between head and projection also to syntactic categories – in other words, recognizing category as a syntactic feature. This led to the development of the much more articulated theory of syntactic features in Gazdar et al. (1985). HPSG took the featural basis of GPSG, fully embracing the "head-driven" approach to the characterization of phrase structure, and extending the attribute-value format to represent every part of the syntactic analysis.

16.4.2.2 Feature Theory

Featural information associated with each word introduces constraints on the well-formedness of the whole structure, within a "monotonic" system: information cannot be selectively ignored, nor can it be changed. Hence declarative frameworks necessarily have a property which has come to feature in MP discourse – the "No Tampering Condition" (Chomsky, 2007).

For instance, (11) is ungrammatical as not all the constraints coming from the lexical items can be satisfied simultaneously, and no part of the information can be ignored:

(11) *You am happy.

you will specify the value of PERSON of the subject as 2, but *am* will specify that same value as 1. The example does not constitute a "failure" of agreement; rather, there is no way to satisfy the requirements of the first two words in a single structure.

Declarative frameworks introduce featural information either via lexical items or by the rules that license phrase structure. Every well-formed feature specification is of the form [attribute: value], by definition. If any lexical item introduces a feature without a value, that is an "unvalued feature," and some other element in the structure must introduce the value for that feature, or else the overall structure will be ill-formed. Although unvalued features play a significant role in MP analyses

(because their function is different from that of representing information, see below), they are much less widespread in declarative analyses, where valued features are the norm.

Using LFG terminology, the basic way for information to be specified is as a "defining" specification – for instance, the information carried by the appropriate formalized entries for the words in (8). There is another kind of contribution, a "constraining" specification, formally known as a "constraining equation." This latter kind of specification is quite commonly used in linguistic analyses, for situations where one element requires not only a feature but a specific value for that feature, but where that entire specification must come from some other element. Kaplan and Bresnan (1982, pp. 207–209) motivate constraining equations with familiar facts such as those in (12), with their proposal for analysis in (13):

(12) A girl is handing (*is hands, *is handed) the baby a toy.
(13) *is*: (↑ XCOMP PARTICIPLE) $=_c$ present

The VP complement of *is* has the grammatical function XCOMP in the LFG analysis, and this is what (13) refers to. It says that in the f-structure corresponding to the constituent containing *is* (from the up arrow), there is an XCOMP attribute, within which there should be a PARTICIPLE attribute with the value "present" – but that information must come from some other element that actually provides the value. In the example in (12), that is due to *handing*, which defines the value "present" for its attribute PARTICIPLE. The important move to a contraining equation over a defining one concerns the ungrammatical variants in (12). For instance, as a finite form, *hands* is not specified at all for the attribute PARTICIPLE, and so does not provide the information that (13) needs. However, if that information in (13) were specified as defining information, it would be unified with the information from *hands*, and – at least on that count – the sequence **is hands* would not be ungrammatical, as nothing would be inconsistent.

This aspect of syntactic analysis is modeled in MP analyses with an "uninterpretable" feature – two elements between which there is some dependency must have the same feature specifications, but only one such specification is the "real one." Formally, there are different ways in which incomplete featural specifications – "underspecified features" – can be used in syntactic analysis (see Kaplan 2018).

16.4.2.3 The Role of Features in Grammatical Analysis

Features are used in various ways in MP analyses that go beyond the simple representational uses described above. They are not only used to represent syntactic information, but are also used to make things happen in a derivation, and in this second use, they must subsequently disappear. The idea of a feature being *un*interpretable and used to establish a syntactic relation comes from the proposal in Chomsky (1995, p. 255):

> … certain features of [lexical items] enter into interpretation at LF while others are uninterpretable and must be eliminated for convergence. We therefore have a crucial distinction ±interpretable. Among the Interpretable features are categorial features and the ϕ-features of nominals. The operations that interpret [*We build airplanes*] at the LF interface will have to know that *build* is a V and airplanes an N with the ϕ-features [plural],

[– human], [3 person]. On the other hand, these operations have no way to interpret the Case of *airplane* or the agreement features of *build*, which must therefore be eliminated for LF convergence.

It is debatable whether the argument here is valid. Agreement features are certainly not *un*interpretable, when analyzed properly, with a lexical representation of valence (as with the predicates in (8)), and the purported uninterpretability of Case has been increasingly questioned (see, e.g. Chomsky et al. 2019, p. 252).

Features are put to at least three uses in MP analyses (see also Adger 2010, pp. 200–212). The first is to represent information, the second is to establish a relationship, and the third is to make something happen. The representational aspect usually involves valued features, and might involve unvalued ones. The second use involves the notion of interpretable and uninterpretable features, which is orthogonal to whether a feature is valued or not, and is the mechanism for establishing a relationship (by *Agree* between a Probe and a Goal; Chomsky 2000, p. 101). Uninterpretable features have two properties that would not be recognized in information-based frameworks – they are necessarily "bad," and they must be eliminated. Declarative frameworks do not allow a local part of the representation to be ill-formed, and they do not allow information to be changed, as they are monotonic. Hence, from the perspective of declarative frameworks, using features to establish syntactic relationships constitutes a significant departure from the core of what features do. As noted above, the LFG notion of constraining equation can be used to account for dependencies, but a structure with (only) a constraining equation for the relevant information is not ill-formed; rather, it is informationally incomplete.

The third use of features in the MP is to trigger an operation, and has no correspondent in declarative approaches. In most MP accounts, internal Merge is triggered by an "EPP-feature" (Chomsky 1995, p. 213) or an "Edge feature" (Chomsky 2007, p. 11). Such features exist to force movement and appear to add to the inventory of syntactic features, and have no direct (featural) counterparts in declarative frameworks.

16.4.3 Structures

16.4.3.1 Heads and Headed Structures

In this subsection I describe the somewhat different approaches of HPSG and LFG with regard to how phrase structures are characterized, though they largely agree on what evidence is relevant for those structures (described in the next section). Here I focus on the notion of "head" and its central syntactic role.

The approach to phrase structure within a declarative approach takes PS-rules to be constraints on trees. Following McCawley (1968), Gazdar (1981, p. 156) (also see Gazdar 1982, pp. 137–139) interpreted the phrase structure component as specifying node admissibility conditions, instead of the traditional "rewrite" system familiar from Chomsky's earliest work. In this way, PS-rules are well-formedness conditions on trees, and a grammar conceived of as a set of PS-rules is a declarative system that characterizes as well-formed any tree from root down to terminals that meets the set of conditions imposed by the relevant rules and terminals.

Gazdar and colleagues developed a version of phrase structure grammar that essentially allowed various kinds of information flow within the phrase structure itself, and that in turn meant that the transformational component could be dispensed with. The PS-rules themselves are schematic, and therefore each rule can admit a large number of local trees, each node of which is specified by featural information that is now quite standardly assumed as part of syntactic information. GPSG also factored out linear order from hierarchical structure early on, in the Immediate Dominance/Linear Precedence (ID/LP) format (e.g. Pullum 1982).

The "head-driven" approach of HPSG licenses structures that satisfy the combinatoric requirements of heads, as is familiar from Categorial Grammar (and Montague Grammar). Each head effectively has a surface valence list, a list of what it needs to combine with to be internally satisfied, ordered according to increasing obliqueness. A ditransitive verb, for instance, would have a valence requirement of <NP, NP, PP>, where the first NP corresponds to the subject and the second to the object.

Local subtrees are licensed by Immediate Dominance rules (ID-rules) – some examples in (14) – which allow different modes of combination. Grammars may differ according to which rules they have. Linear precedence is separate, so for instance (14d) licenses a flat structure of a head and all its arguments; languages with this structure can vary as to whether the head is linearized as initial, or final, or not at all.

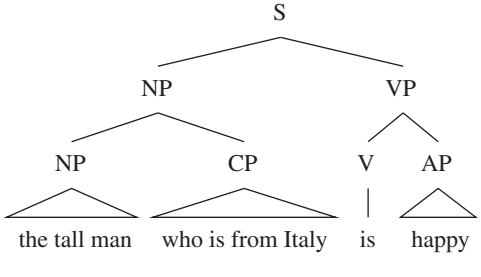
(14) a. Combine with one argument at a time.
"binary branching"
b. Combine with all arguments except the highest one.
"create a flat VP"
c. Combine with exactly one remaining argument.
"combine with a specifier"
d. Combine with all arguments at once.
"create a flat structure"

The way that different structures are licensed is the basis of the account of the difference between (15a) and (15b) (cf. the examples in section 3.1 above):

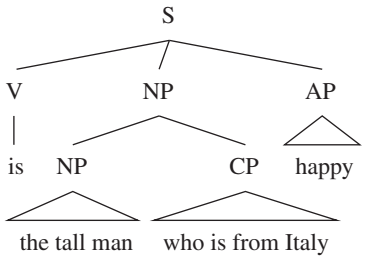
(15) a. The tall man who is from Italy is happy.
b. Is the tall man who is from Italy happy?

The auxiliary *is* is the head of each clausal structure, and its surface valence list is <NP, AP> for the main clause. For (15a), *is* heads a VP, which is formed according to (14b), which then combines with its specifier according to (14c), while for (15b), *is* combines with its arguments all at once, following (14d).

(16) a.



b.



The learnability problem of interrogative clause vs. declarative clause in English is one of recognizing different modes of combination of the main clause head (*is*). As the grammar gives a direct representation of each clause, any information concerning an embedded clause (such as the contribution of the relative clause *is*) would never be considered.

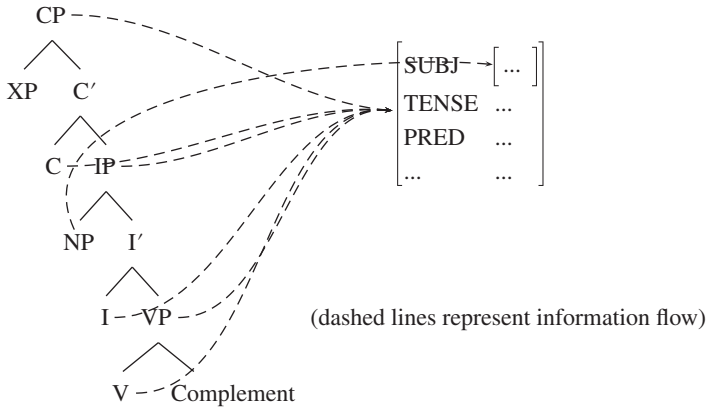
HPSG has a commitment to a certain kind of X′-theory, with different kinds of branchingness, as (16) suggest. It effectively instantiates a version of 'Bare Phrase Structure' (Chomsky 1995, pp. 242ff.), as it has no formal bar levels from X′-theory, but only the notions of "constituent whose head's valence is not fully saturated" opposed to "constituent whose head's valence is fully saturated." The equivalences in (17) illustrate; formally the categories on the left are convenient and familiar notations, but the rules and principles of grammar only refer to categories such as V or N, and the degree of saturation.

(17) a. VP ≡ V saturated except for the highest argument NP
b. S ≡ fully saturated V
c. NP ≡ fully saturated N

Even with such a bare approach, it is necessary to distinguish word-level categories from those that are some phrasal projection (e.g. licensed by any of (16)), which has been accomplished in HPSG by the feature [LEX] with values + or − (Pollard and Sag, 1987). The same notion has recently been argued to be necessary for MP derivations in Rizzi (2016b) (cf. the discussion of minimal and maximal projections in Chomsky op. cit.).

The LFG approach to phrase structure is different. The structures, known as c[onstituent]-structures, have similarities with the S-structures of late GB. A canonical clause (for an SVO language) is structured around what I refer to as a "skeleton" with a "spine" (Sells 2001, p. 17). (18) shows the skeleton, and the spine corresponds to all the non-argumental parts, V, I, C and their projections. These are separate categories which participate in the familiar clausal extended projection (Grimshaw, 2000, pp. 116ff.; Bresnan, 2001, p. 100), often now referred to as the "Hierarchy of Projections" (Adger 2003). The core structure has specifiers of CP and IP, and complement position(s) within VP, schematized here with the placeholder label Complement.

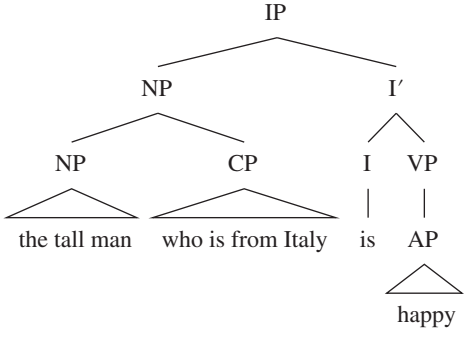
(18)



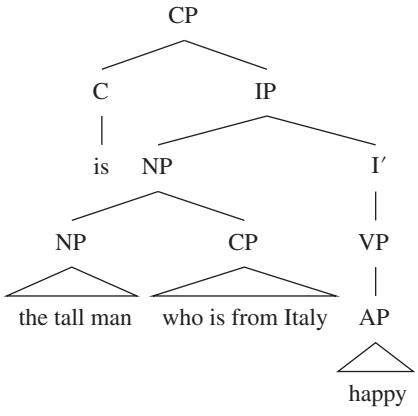
Each node in the c-structure is annotated as to how it contributes to the f-structure. The formal annotations on nodes are not shown in (18), for simplicity, but rather the dashed lines represent the way that information flows from the c-structure to the f-structure. Every node in the clausal spine contributes its information to the main f-structure, as can be seen from the several lines converging on the outer f-structure, which represents the grammatical information of the clause. Hence as far as clausal information is concerned, the verb itself contributes identically to the clause whether it is in V or in I or in C, a property usually referred to as 'head mobility' (see e.g. Bresnan 2001, pp. 126ff.; Bresnan et al. 2016, pp. 129ff.). The other nodes, XP, NP, and Complement, have different annotations on them, as they contribute to parts of the overall f-structure. For instance, the annotation on the node NP would indicate that its contribution is as the subject – in other words, NP as specifier of IP is the subject position. This is indicated by the dashed line going from NP in the c-structure to the value of SUBJ in the f-structure.

The LFG c-structures for the examples in (15) are in (19), and bear a resemblance to the overt parts of GB S-structures:

(19) a.



b.



In (19a) VP lacks a c-structure head V, and in (19b), both IP and VP lack their X^0 heads. The theory requires that every XP either has a c-structure head in the standard X′ sense, or that it maps to an f-structure shared with at least one YP, which is headed in c-structure. Such a Y^0 is known as the 'extended head' of XP (the notion is originally due to Zaenen and Kaplan, 1995, p. 221, revised to the formulation given here by Bresnan, 2000, p. 353). So in (19a), I is the extended head of VP, and in (19b), C is the extended head of IP and of VP, leading to the illusion that the head is moving.

Once again, the learnability problem of (15) is the recognition that the second example involves a different surface expression of essentially the same information at the main clause level. The only positional options for the finite verb are V, I, or C; whatever is happening with the relative clause within the subject, that is a separate clause whose properties do not overlap with the main clause.

The discourse in the MP literature over the past 25 years as to whether head movement exists or whether it is part of "narrow syntax" (see e.g. Roberts 2011; Harizanov and Gribanova 2019 for overviews) is quite puzzling from the perspective of declarative frameworks, as heads are central to the syntactic analysis. The issue arose as position-occupying head movement does not obey the Extension Condition of Chomsky (1995), requiring that every operation of Merge extends the root node of the current tree. Head movement violates this condition, and consequently Chomsky raised the issue of the status of head movement (e.g. Chomsky 2000, pp. 136–137; Chomsky 2001, p. 38).

16.4.3.2 Phrase Structures Are Not Isomorphic to Clausal Information

The Mandarin Verb Copy Construction (Li and Thompson 1981; Huang 1982) serves to illustrate why and how the phrase structure part of the representation is distinct from the representation of clausal grammatical information. Postverbal arguments and adjuncts appear to be in competition within a single VP: in order to express an argument and an adjunct, the main verb must be duplicated to form a second VP, as in (20b).

(20) a. *Zhangsan xue zhongwen de hen hao
Zhangsan study Chinese LNK very well
"Zhangsan studies/studied Chinese very well."

b. Zhangsan xue zhongwen xue de hen hao
Zhangsan study Chinese study LNK very well
"Zhangsan studies/studied Chinese very well."

Huang (1982) proposed a phrase structure filter that essentially disallows arguments and adjuncts in the same VP. Fang and Sells (2007) note that both arguments of a ditransitive verb appear in the first VP (underlined in (21a)), and that an object may be displaced from within the first VP, otherwise preserving the phrase structure:

(21) a. wo song <u>ta</u> <u>zhe jian liwu</u> song de hen hao
I give him this CL gift give LNK very well
"I gave him this gift and it turned out to be a very good idea."

b. <u>zhe jian liwu</u> wo song ta _ song de hen hao
this CL gift I give him _ give LNK very good
"This gift, I gave (it) him and (it turned out to be) very good."

However, if an object is displaced from a monotransitive VP, verb "copying" is no longer an option (also see Huang 1982, p. 53):

(22) a. *<u>gangqin</u> Zhangsan tan _ tan de hen hao
piano Zhangsan play _ play LNK very well

b. <u>gangqin</u> Zhangsan tan _ de hen hao
piano Zhangsan play _ LNK very well
"The piano, Zhangsan played (it) a long time."

Such examples show that the competition between arguments and adjuncts for the same VP is a phrase-structure phenomenon, and is not relevant for the level of clausal grammatical information: a verb in Mandarin can perfectly well have a full array of arguments and any adjuncts, but only some of those can be expressed within a single VP. In a careful survey of the research on this topic, Bartos (2019) has to appeal to haplology of V to derive (22b) from (22a) (already suggested in Huang, 1982, p. 99), but this is merely symptomatic of an underlying misanalysis: the core relations between a predicate and its (surface) arguments and adjuncts are not primarily mediated by phrase structure.

As movement moves units of syntactic substance, a derivational analysis of (22) necessarily involves two initial occurrences of *which* that are amalgamated into a single one in the final surface position. There are many proposals for solutions to this problem, but the problem only arises due to the procedural view. Reference to syntactic information independently of the structure that expresses it is a key point of contrast between declarative and procedural perspectives. A declarative perspective leads to the question "What is true?" rather than "What has to happen to make it so?".

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16.5 Conclusion

Declarative frameworks instantiate an approach to syntax entirely consistent with the goals that Chomsky set for Generative Grammar, but in which there is no derivation, and no direction of procedural operations over representations. In the MP, those operations are used to establish various syntactic relationships, for instance agreement between a head and an argument, or a licensing mechanism for an NPI. On a declarative view, such relationships are informationally encoded in lexical items.

I discussed in Section 16.2.1.2 how the MP has maintained a representational component, as each step in a derivation involves a certain amount of structure which some operation such as Minimal Search (Chomsky, 2007) can inspect. Several aspects of the approach to representation that have emerged during the evolution of the MP analyses are already instantiated in declarative frameworks.

As Chomsky has noted, the choice between grammatical frameworks can be understood in terms of the "extra burdens" that an overexuberant approach will entail. From a declarative perspective, any procedural approach creates such burdens, as the necessary mechanisms are either too powerful or are not well-founded. If those mechanisms can change or even delete syntactic information or syntactic substance, it is necessary to contrain those destructive operations with the "No Tampering Condition" – indeed, a very natural property of a grammatical system, but one that should be intrinsic to it.

A different burden falls on the feature system of the MP, as features are used to do more than represent information (section 16.4.2). It becomes necessary to posit "bad" feature specifications, such as uninterpretable features, which by design are not interpretable on their hosts, and which must be eliminated during the derivation. Declarative frameworks have mechanisms of a different character for checking that certain grammatical relationships exist, and which do not involve recourse to local pockets of ill-formedness or incoherence.

Finally, the "copy theory" of movement (Chomsky, 1995) is a way of expressing the intuition that some information is shared. However, copies involve duplication of substance, which amounts to more than the sharing of information. The discussion of structure in 16.4.3 provides a perspective on two kinds of further burden that necessarily arise in a copy-based approach. First, with regard to head mobility, I showed how a declarative view considers the issue to be one of alternative positions, rather than successive positions which exist to provide hosts for position-occupying movement. The head is indeed only "in" one head position, but it makes the same contribution that it would have made from any of its alternative possible positions, and so might appear as if it were contributing from each position. A recent MP account of the syntax of heads by Arregi and Pietrasko (2020) associates only the informational part of a given head with several head positions, effectively recapitulating the LFG analysis of head mobility through various operations to create the right representations. Second, the facts of Mandarin verb copying and English coordinate structures show that certain parts of the syntactic analysis indeed call for a duplication of substance (when there are both in-situ arguments and adjuncts in Mandarin), while other parts involve more abstract syntactic information (the notion of a verb *having* arguments and having adjuncts). If that abstract information is conflated with substance, the system generates too much, and then extra operations have to be invoked, pruning or conflating substance.

In conclusion, Chomsky showed that the way to study language is to study knowledge of language, which itself is a systematic body of knowledge. Declarative frameworks take their inspiration from these foundational observations, setting out to answer the question of how that knowledge is represented or characterized, as outlined above in Sections 16.1 and 16.2. These frameworks take up the challenges of accounting for human language precisely as Chomsky first articulated them, then continuing with a view quite different from his as to what the core non-negotiable properties of the syntactic system should be. In Section 16.3 I showed how declarative frameworks did not stay locked into the procedures for generating and manipulating phrase structure representations of the early era. Instead, they have developed as systematic and coherent frameworks for representation of grammatical information, based on certain key design features. While these design features give these frameworks a very different character from a procedural framework such as the MP, many of the components of analysis that MP has developed are already present in declarative frameworks (Section 16.4), as is the convergence of interest in exploring "third factor" considerations (see (6)).

Endnote

1 The final version of this chapter has benefitted from comments and input from an anonymous reviewer, Ronald M. Kaplan, Shin-Sook Kim, and Geoffrey K. Pullum. Further particular thanks are due to Terje Lohndal for his comments, input and ongoing support. Naturally I am responsible for any errors or misinterpretations that remain.

References

Adger, David. 2003. *Core Syntax: A Minimalist Approach*. Oxford: Oxford University Press.

Adger, David. 2010. A Minimalist theory of feature structure. In *Features: Perspectives on a key notion in linguistics*, ed. Anna Kibort and Greville G. Corbett, 185–218. Oxford: Oxford University Press.

Arregi, Karlos, and Asia Pietrasko. 2020. The ups and downs of head displacement. *Linguistic Inquiry* in press.

Baker, Mark C. 1985. The Mirror Principle and morphosyntactic explanation. *Linguistic Inquiry* 16:373–415.

Bartos, Huba. 2019. The V-copy construction in Mandarin: A case temporarily reopened. In *Interfaces in grammar*, ed. Jianhua Hu and Haihua Pan, 167–205. Amsterdam: John Benjamins.

Bresnan, Joan. 2000. Optimal syntax. In *Optimality theory: Phonology, syntax and acquisition*, ed. Joost Dekkers, Frank van der Leeuw, and Jeroen van de Weijer, 334–385. Oxford: Oxford University Press.

Bresnan, Joan. 2001. *Lexical-functional syntax*. Oxford: Blackwell.

Bresnan, Joan, Ash Asudeh, Ida Toivonen, and Stephen Wechsler. 2016. *Lexical-Functional Syntax*. Malden, MA: Wiley Blackwell.

Chomsky, Noam. 1964. *Current issues in linguistic theory*. The Hague/Paris: Mouton.

Chomsky, Noam. 1965. *Aspects of the theory of syntax*. Cambridge, MA: MIT Press.

Chomsky, Noam. 1970. Remarks on nominalization. In *Readings on English transformational grammar*, ed. Roderick A. Jacobs and Peter S. Rosenbaum, 184–221. Waltham, MA: Ginn.

Chomsky, Noam. 1973. Conditions on transformations. In *A festschrift for Morris Halle*, ed. Stephen R. Anderson and Paul Kiparsky, 232–286. New York: Holt, Rinehart and Winston.

Chomsky, Noam. 1981. *Lectures on Government and Binding*. Dordrecht: Foris.

Chomsky, Noam. 1995. *The Minimalist Program*. Cambridge: MIT Press.

Chomsky, Noam. 2000. Minimalist inquiries: the framework. In *Step by step: Essays on Minimalist Syntax in Honor of Howard Lasnik*, ed. Roger Martin, David Michaels, and Juan Uriagereka, 89–155. Cambridge: MIT Press.

Chomsky, Noam. 2001. Derivation by phase. In *Ken Hale: A Life in Language*, ed. Michael Kenstowicz, 1–52. Cambridge: MIT Press.

Chomsky, Noam. 2005. Three factors in language design. *Linguistic Inquiry* 36:1–22.

Chomsky, Noam. 2007. Approaching UG from below. In *Interfaces + recursion = language? Chomsky's Minimalism and the View from Syntax-Semantics*, ed. Uli Sauerland and Hans-Martin Gärtner, 1–29. Berlin: Walter de Gruyter.

Chomsky, Noam, Ángel J. Gallego, and Dennis Ott. 2019. Generative Grammar and the Faculty of Language: Insights, Questions, and Challenges. In *Catalan Journal of Linguistics (special issue): Generative Syntax. Questions, Crossroads, and Challenges*, ed. Ángel J. Gallego and Dennis Ott, 229–261.

D'Alessandro, Roberta. 2019. The achievements of Generative Syntax: a time chart and some reflections. In *Catalan Journal of Linguistics (special issue): Generative Syntax. Questions, Crossroads, and Challenges*, ed. Ángel J. Gallego and Dennis Ott, 7–26.

Dalrymple, Mary. 2001. *Lexical-Functional Grammar (Syntax and Semantics 34)*. New York: Academic Press.

Emonds, Joseph E. 1976. *A Transformational Approach to English Syntax: Root, Structure-preserving, and Local Transformations*. New York: Academic Press.

Fang, Ji, and Peter Sells. 2007. A formal analysis of the verb copy construction in Chinese. In *Proceedings of the LFG-07 conference*, ed. Miriam Butt and Tracy Holloway King, 198–213. Stanford: CSLI Publications.

Gazdar, Gerald. 1981. Unbounded dependencies and coordinate structure. *Linguistic Inquiry* 12:155–184.

Gazdar, Gerald. 1982. Phrase structure grammar. In *The Nature of Syntactic Representation*, ed. Pauline Jacobson and Geoffrey K. Pullum, 131–186. Dordrecht: Reidel.

Gazdar, Gerald, Ewan Klein, Geoffrey K. Pullum, and Ivan A. Sag. 1985. *Generalized Phrase Structure Grammar*. Cambridge: Harvard University Press.

Grimshaw, Jane. 2000. Locality and extended projection. In *Lexical Specification and Insertion*, ed. Peter Coopmans, Martin Everaert, and Jane Grimshaw, 115–133. Amsterdam/Philadelphia: John Benjamins.

Harizanov, Boris, and Vera Gribanova. 2019. Whither head movement? *Natural Language and Linguistic Theory* 37:461–522.

Hornstein,Norbert. 2018. The Minimalist Program after 25 years. *Annual Review of Linguistics* 4:49–65.

Huang, C.-T. James. 1982. Logical relations in Chinese and the theory of grammar. Doctoral Dissertation, MIT.

Hudson, Richard. 1977. The power of morphological rules. *Lingua* 42:73–89.

Jackendoff, Ray. 1972. *Semantic Interpretation in Generative Grammar*. Cambridge, MA: MIT Press.

Kaplan, Ronald M. 2018. Formal aspects of underspecified features. In *Tokens of Meaning: Papers in honor of Lauri Karttunen*, ed. Cleo Condoravdi and Tracy Holloway King, 349–369. Stanford: CSLI Publications.

Kaplan, Ronald M., and Joan Bresnan. 1982. Lexical-Functional Grammar: A formal system for grammatical representation. In *The Mental Representation of Grammatical Relations*, ed. Joan Bresnan, 173–281. Cambridge: MIT Press.

Keenan, Edward L. 1976. Towards a universal definition of subject. In *Subject and Topic*, ed. Charles Li, 303–333. New York: Academic Press.

Li, Charles N., and Sandra A. Thompson. 1981. *Mandarin Chinese: A Functional Reference Grammar*. Berkeley and Los Angeles: University of California Press.

Manning, Christopher D. 1996. *Ergativity: Argument Structure and Grammatical Relations*. Stanford: CSLI Publications.

McCawley, James D. 1968. Concerning the base component of a transformational grammar. *Foundations of Language* 4: 243–269. (Reprinted 1973 in James D. McCawley, *Grammar and Meaning*. New York, Academic Press; Tokyo, Taishukan, 35–58).

Miller, George A., and Noam Chomsky. 1963. Finitary models of language users. In *Handbook of Mathematical Psychology, Volume II*, ed. R. Duncan Luce, Robert R. Bush, and Eugene Galanter, 419–491. New York and London: John Wiley and Sons, Inc.

Müller, Stefan. 2016. *Grammatical theory: From Transformational Grammar to Constraint-Based Approaches*. Berlin: Language Science Press.

Müller, Stefan, and Stephen Wechsler. 2014. Lexical approaches to argument structure. *Theoretical Linguistics* 40 (1-2): 1–76.

O'Grady, William. 2012. Three factors in the design and acquisition of language. *Wiley Interdisciplinary Reviews: Cognitive Science* 3: 493–499.

Pollard, Carl, and Ivan A. Sag. 1987. *Information-Based Syntax and Semantics*. Stanford: CSLI Publications.

Pollard, Carl, and Ivan A. Sag. 1994. *Head-Driven Phrase Structure Grammar*. Chicago: University of Chicago Press.

Pullum, Geoffrey K. 1982. Free word order and phrase structure rules. In *Proceedings of the Twelfth annual meeting of the North Eastern Linguistic Society*, ed. James Pustejovsky and Peter Sells, 209–220. Amherst, MA: GLSA.

Pullum, Geoffrey K. 2013. The central question in comparative syntactic metatheory. *Mind and Language* 28(4): 492–521.

Pullum, Geoffrey K., and Barbara C. Scholtz. 2002. Empirical assessment of stimulus poverty arguments. *The Linguistic Review* 19: 9–50.

Rizzi, Luigi. 2016a. The concept of explanatory adequacy. In *The Oxford Handbook of Universal Grammar*, ed. Ian Roberts, 97–113. Oxford: Oxford University Press.

Rizzi, Luigi. 2016b. Labeling, maximality and the head–phrase distinction. *Linguistic Review* 33(1): 103–127.

Roberts, Ian. 2011. Head movement and the Minimalist Program. In *The Oxford Handbook of Linguistic Minimalism*, ed. Cedric Boeckx, 195–219. Oxford: Oxford University Press.

Sag, Ivan A., Thomas Wasow, and Emily Bender. 2003. *Syntactic Theory: A Formal Introduction*. Stanford: CSLI Publications.

Schachter, Paul. 1976. The subject in Philippine languages: Actor, topic, actor-topic, or none of the above. In *Subject and Topic*, ed. Charles N. Li, 491–518. New York: Academic Press.

Sells, Peter. 2001. *Structure, Alignment and Optimality in Swedish*. Stanford: CSLI Publications.

Wechsler, Stephen, and I Wayan Arka. 1998. Syntactic ergativity in Balinese: An argument structure based theory. *Natural Language and Linguistic Theory* 16:387–442.

Zaenen, Annie, and Ronald M. Kaplan. 1995. Formal devices for linguistic generalizations: West Germanic word order in LFG. In *Formal Issues in Lexical-Functional Grammar*, ed. Mary Dalrymple, Ronald M. Kaplan, John T. Maxwell III, and Annie Zaenen, 215–239. Stanford: CSLI Publications.

17

How Statistical Learning Can Play Well with Universal Grammar

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17.1 Introduction

A key motivation for Universal Grammar (UG) is developmental: UG can help children acquire the linguistic knowledge that they do as quickly as they do from the data that's available to them (Chomsky 1981; Jackendoff 1994; Laurence and Margolis 2001; Crain and Pietroski 2002). That is, UG allows children to solve what Chomsky (1965, 1975, 1980a,b) and many subsequent others (see Pearl 2019 for a recent review) have called the *poverty of the stimulus*, where the available data often seem woefully inadequate for pinpointing the right linguistic knowledge as efficiently as children seem to. So, without some internal bias, children would be lost when it comes to language acquisition. Enter UG: a concrete proposal for what that internal bias could be that enables language acquisition to succeed.

Among other things, UG provides a way to structure a child's hypothesis space about the linguistic system – what explicit hypotheses are considered, and (perhaps more importantly) what building blocks allow children to construct those explicit hypotheses for consideration. For example, traditional linguistic macro-parameters (Chomsky 1981, 1986) are building blocks that children can construct language grammars from – that is, a language's grammar would be a specific collection of parameter values for these linguistic parameters. An example parameter might be whether relational words like *on* come before or after their objects – if these words come before (as in English, Hebrew, and Igbo) they're called prepositions; if they come after (as in Cherokee, Hungarian, and Japanese), they're called postpositions. So, having prepositions would be one parameter value while having postpositions would be another for this parameter. Having these parameter building blocks then allows a child to construct and consider explicit hypotheses about a language's grammar as language data are encountered.

However, setting such parameters from the available language data is a *hard* problem, which is why a lot of energy has been devoted to figuring out how that process could work (e.g. see the more detailed discussion of this body of work in Pearl (in press)).

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In particular, parameter setting is hard even if UG allows the child to already know which parameters there are and which parameter values are possible for each parameter. The problem is simply that the hypothesis space is vast (e.g. *n* binary parameters yield 2^n possible grammars – this number gets very big very quickly); also, the child's input data are often ambiguous between different grammars.

One plausible solution to the parameter-setting problem relies on reinforcement learning – a domain-general statistical learning mechanism – applied to linguistic parameter values (see Pearl (in press) for more discussion on this approach implemented by Yang 2002, 2004; Legate and Yang 2007; Yang 2012; and Legate and Yang 2013). Relatedly, some of the most fruitful recent work in language acquisition has combined ideas about different hypothesis space building blocks with domain-general statistical learning (e.g. Piantadosi et al. 2012; Orita et al. 2013, Pearl and Sprouse 2013a; Abend et al. 2017; Pearl and Sprouse (in press)).

What all these approaches to language acquisition demonstrate is that statistical learning only works in tandem with a predefined hypothesis space. To me, this is one key legacy of Chomsky's work in the area of language acquisition: statistical learning by itself can't be an answer to how children learn the linguistic representations they do. More specifically, Chomsky highlighted that children's hypothesis space of representations is a crucial component in the language acquisition process – and therefore, understanding the nature of that hypothesis space is a concrete way to make progress in understanding how language acquisition proceeds. Statistical learning can then provide a way to help navigate the hypothesis space (e.g. of possible grammars) in order to converge on the correct hypothesis (e.g. a specific language's grammar). In this way, statistical learning can complement the prior knowledge that defines the hypothesis space – but statistical learning does *not* itself define the hypothesis space and so could never replace prior knowledge that does in fact define the hypothesis space. So, any components of UG that define the child's linguistic hypothesis space are not replaceable by statistical learning. However, any components of UG that involve navigating the hypothesis space *may* be replaceable by statistical learning. And, perhaps by considering other ways of navigating a predefined hypothesis space, we may be able to refine our ideas about the UG knowledge that constructs that hypothesis space in the first place.

Below, I explore these ideas more concretely – cognitively plausible statistical learning mechanisms, how statistical learning can complement UG, and how statistical learning can help us refine our ideas about what's in UG. I'll first give a brief overview of statistical learning mechanisms we have evidence for in small humans, along with some illustrative examples. This evidence is the foundation for talking about statistical learning at all for language acquisition – if these mechanisms aren't there in small humans, there's no need to spend energy thinking about how they might be used by small humans learning language. But, if statistical learning mechanisms are in fact there and usable by small humans, we have motivation for thinking about how children might leverage them during language acquisition.

I'll then discuss some examples where statistical learning complements UG, which happens when statistical learning offers a way to efficiently navigate the hypothesis space defined by UG. I'll then turn to some examples where statistical learning can replace prior UG proposals for navigating a hypothesis space; this can lead to new ideas for how the hypothesis space might be constructed in the first place. I'll conclude briefly with what I think is a concrete way to make progress on understanding the process of language acquisition, integrating what we know about statistical learning.

17.2 Statistical Learning Mechanisms in Small Humans

At its core, statistical learning is about counting things (this is the "statistical" part), and updating hypotheses on the basis of those counts (this is the "learning" part, sometimes also called *inference* (Pearl in press)). Counting things is a domain-general ability, because we can count lots of different things (both linguistic and nonlinguistic). So, to effectively use statistical learning, a child has to know what to count. These counts can then be converted into probabilities (for example, seeing something 3 times out of 10 yields a probability of $\frac{3}{10} = 0.30$); then, things with higher probabilities can be interpreted as more likely than things with lower probabilities.

For language acquisition, counting things often means counting linguistic things. Importantly, what the child might be counting often depends on the representational and learning theories we currently have for the linguistic knowledge to be acquired and children's developing representation and processing capacities (Pearl, in press). For instance, depending on the theories involved, a child acquiring syntactic knowledge might be doing inference over counts of lexical items (Yang 2005; Freudenthal et al. 2007, 2009, 2010, 2015; Yang 2016, 2017), syntactic category sequences (Perfors et al. 2010, 2011a; Pearl and Sprouse 2013a), syntactic signals realized in certain overt structures (Sakas and Fodor 2001; Yang 2004; Legate and Yang 2007; Mitchener and Becker 2010; Pearl and Sprouse 2013a; Becker 2014; Sakas 2016; Pearl and Sprouse 2019), or something else entirely. Importantly, the statistical learning mechanism itself doesn't seem to change – once the child knows the units over which inference is operating, counts of the relevant units are collected and inference can operate.

Also importantly, we have good reason to think that small humans are good at both counting things and doing inference over those counts. There's a lot of evidence that infants under a year old are capable of exactly this (nine-month-olds: Fiser and Aslin 2002, Wu et al. 2011; eight-month-olds: Saffran et al. 1996, Aslin et al. 1998, Saffran et al. 1999, Stahl et al. 2014, Aslin 2017; two-month-olds: Kirkham et al. 2002; newborns: Ferry et al. 2016, Fló et al. 2019; among many other studies). So, statistical learning isn't unreasonable to think about as something children *could* use during language acquisition. Happily, we have several current proposals for useful ways children could harness statistical learning for language acquisition, which I'll briefly review below.[1]

17.2.1 Some Ways of Doing Statistical Learning

17.2.1.1 Reinforcement Learning

Reinforcement learning (see Sutton and Barto (2018) for a recent overview) is a principled way to update the probability of a categorical option that's in competition with other categorical options. So, if we're thinking in terms of linguistic parameters, perhaps a child might consider a parameter that controls whether *wh*-movement is required as the default in questions (such as in English, with the *wh*-word *what* in *What's Jack climbing* t_{what}*?* = +wh-movement), or whether the *wh*-word can remain in-situ (such as in Japanese = –*wh*-movement). As mentioned above, Yang & Legate's approach relies on reinforcement learning and uses an implementation by Bush and Mosteller (1951) called the linear reward-penalty scheme. As the name suggests, there are two choices when a data point is processed – either the categorical option under consideration is rewarded or it's penalized. This translates to the option's current

probability being increased (rewarded) or decreased (penalized). For instance, if the +*wh*-movement option is under consideration, and it's compatible with the current data point (like *What's Jack climbing* t_{what}*?*), the +*wh*-movement option is rewarded and its probability is increased. In contrast, if that same option is under consideration, but it's not compatible with the current data point (such as an echo question like *Jack's climbing what?!*), the +*wh*-movement option is penalized and its probability is decreased.

While applying reinforcement learning to linguistic parameters is a fairly recent innovation, reinforcement learning itself is well-supported in the child development literature more generally (sometimes under the name "operant conditioning"). In particular, we have evidence that very young children are capable of it (under 18 months: Hulsebus 1974; 12 months: Lipsitt et al. 1966; 10 months: de Sousa et al. 2015; 3 months: Rovee-Collier and Capatides 1979; 10 weeks: Rovee and Rovee 1969, Watson 1969; among many others). So, it's plausible that young children could use reinforcement learning for language acquisition.

17.2.1.2 The Tolerance and Sufficiency Principles

The Tolerance and Sufficiency Principles (Yang 2005, 2016) together describe a particular inference mechanism, and this mechanism operates over specific kinds of counts that have already been collected. More specifically, these principles together provide a formal approach for when a child would choose to adopt a "rule," generalization, or default pattern to account for a set of items. For example, is there a general rule for forming the past tense in English from a verb's root form (e.g., *kiss* → *kissed*), a generalization about how thematic roles connect to their syntactic positions (e.g. is the AGENT often linked to the *subject* syntactic position), or a default stress pattern for three-syllable English words (e.g. is the stress pattern in *óctopus* typical)?

Both principles are based on cognitive considerations of knowledge storage and retrieval in real time, incorporating how frequently individual items occur, the absolute ranking of items by frequency, and serial memory access. The learning innovation of these principles is that they're designed for situations where there are exceptions to a potential rule. In the examples above, there are certainly exceptions in the child's input: past tense forms like *drank* (rather than *drinked*), non-AGENTs appearing in the *subject* position (*Jack*$_{\text{PATIENT}}$ *got kissed*), and three-syllable words with different stress patterns like *horízon*.

So, these two principles help the child infer whether the rule is robust enough to bother with, despite the exceptions. In particular, a rule should be bothered with if it speeds up average retrieval time for any item. For instance, it's faster on average to have (i) a past tense rule to retrieve a regular past tense form, (ii) a linking rule to retrieve a thematic role reliably associated with a syntactic position, or a syntactic position reliably associated with a thematic role, and (iii) a metrical stress rule to retrieve a predictable metrical stress pattern. However, if the past tense is too irregular, the link too unreliable, or the metrical stress too unpredictable, it's not useful to have the rule: retrieving the target information takes too long on average.

The Tolerance Principle determines how many exceptions a rule can "tolerate" in the data before it's not worthwhile for the child to have that rule at all; the Sufficiency Principle uses that tolerance threshold to determine how many rule-abiding items are

"sufficient" in the data to justify having the rule. This means that the child needs to have previously counted how many items obey the potential rule and how many don't. With these counts in hand, the child can then apply the Tolerance and Sufficiency Principles to infer whether the data justify the adoption of the rule under consideration (or not).

Together, these two principles have been used for investigating a rule, generalization, or default pattern for a variety of linguistic knowledge types, including English past-tense morphology (Yang 2005, 2016), English noun pluralization (Yang 2016), German noun pluralization (Yang 2005), English nominalization (Yang 2016), English metrical stress (Legate and Yang 2013; Yang 2015; Pearl et al. 2017), English *a*-adjective morphosyntax (Yang 2015, 2016), English dative alternations (Yang 2016, 2017), noun morphology in an artificial language (Schuler et al. 2016), linking theories in English (Pearl and Sprouse 2019), and the development of causative use in English (Irani 2019). However, there isn't yet much evidence that children are capable of using the Tolerance and Sufficiency Principles – the main support comes from the study by Schuler et al. (2016), which demonstrates that five- to eight-year-old behavior is consistent with children using these principles. Still, these principles seem like a promising statistical learning mechanism.

17.2.1.3 Bayesian Inference

Bayesian inference operates over probabilities, and involves both prior assumptions about the probability of different options (typically referred to as hypotheses) and an estimation of how well a given hypothesis fits the data. A Bayesian model assumes the learner (for our purposes, the modeled child) has some space of hypotheses H, each of which represents a possible explanation for how the data D in the relevant part of the child's input were generated. For example, a child might consider both a +*wh*-movement option and a -wh-movement option as two hypotheses ($\{$+*wh*-movement, –*wh*-movement$\} \in H$), while the data might be the collection of questions in the child's input involving *wh*-words ($\{$*What did Jack climb?, Jack climbed what?!, …* $\} \in D$).

Given D, the modeled child's goal is to determine the probability of each possible hypothesis $h \in H$, written as $P(h|D)$, which is called the *posterior* for that hypothesis. This is calculated via Bayes' theorem, as shown in (1), which involves two key components: the *likelihood* of the data, given the hypothesis ($P(D|h)$), and the *prior* of the hypothesis ($P(h)$).

(1) $P(h|D) \propto P(D|h) * P(h)$

The likelihood $P(D|h)$ captures how compatible hypothesis h is with the data D: hypotheses with a poor fit to the data (e.g., the –*wh*-movement hypothesis for a dataset with 30% of the data compatible only with +*wh*-movement) have a lower likelihood; hypotheses with a good fit to the data have a higher likelihood. The prior $P(h)$ captures how plausible the hypothesis is, irrespective of its fit to the data. This is often where considerations about the complexity of the hypothesis will be implemented (e.g. considerations of simplicity or economy, such as those included in the grammar evaluation

metrics of Chomsky 1965, and those explicitly implemented in Perfors et al. 2011b and Piantadosi et al. 2012). For example, more complex hypotheses will typically have lower prior probabilities.

Importantly from a developmental perspective, there's a considerable body of evidence suggesting that young children are capable of Bayesian inference (three years: Xu and Tenenbaum 2007; nine months: Gerken 2006, Dewar and Xu 2010, Gerken 2010; six months: Denison et al. 2011, among many others). Given this, Bayesian inference seems a plausible statistical learning mechanism for language acquisition.

17.2.2 Why Statistical Learning in Small Humans Shouldn't Alarm People Who Like UG

What all these statistical learning approaches demonstrate is that there are in fact several cognitively plausible statistical learning mechanisms that children could harness for language acquisition. (Of course, how children would know which one to use for which language acquisition problem is another question.) Perhaps more importantly, there are linguistically savvy ways to harness those mechanisms. That is, being able to count things and do inference over those counts doesn't negate the need to figure out what to count. This key point about what to count is echoed outside the UG-supporting community as well – for example, see the discussion on this point in Scholz and Pullum (2006).

Within the generative linguistics community, there are several examples of researchers who take both statistical learning and theories of linguistic representation very seriously; their studies demonstrate how linguistically savvy statistical learning can yield informative results about both language acquisition and the linguistic representations being acquired (e.g. parameter setting in syntax (Yang 2002, 2004, 2012), parameter setting in metrical phonology (Legate and Yang 2013; Pearl et al. 2017), phonetic category acquisition (Feldman et al. 2013), morphosyntactic acquisition (Yang 2005, 2015, 2016), pronoun acquisition (Orita et al. 2013; Pearl and Mis 2016), syntactic island acquisition (Pearl and Sprouse 2013a), linking theory acquisition (Pearl and Sprouse in press, 2019), as well as many other examples of syntactic acquisition discussed in Pearl (in press)).

So, these studies allow us to see how statistical learning can complement the innate language-specific structure that UG can provide. I also want to highlight a strong connection between one statistical learning mechanism, Bayesian inference, and the intuition of linguistic macro-parameters (Chomsky 1981). I think this connection underscores the potential that statistical learning has to aid theories of language acquisition that rely on UG – and this connection is a ripe avenue for future investigation.

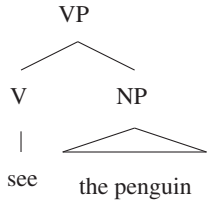
The key idea is that Bayesian inference can be implemented over a hierarchical hypothesis space, such that there are different levels of abstraction for the hypothesis space (Goodman 1955; Kemp et al. 2007; Kemp and Tenenbaum 2008). In particular, there may be narrower hypotheses about certain observable properties, and more abstract hypotheses (called *overhypotheses*) about the nature of those narrower hypotheses. A concrete example taken from Pearl and Lidz (2013) helps demonstrate this intuition, specifically linking it to the concept of linguistic macro-parameters.

Suppose an English-learning child has a collection of utterances in her data *D*. Some utterances contain verbs and objects, and whenever there's an object, suppose it appears

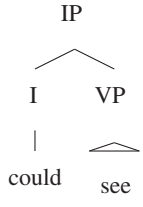
after the verb, e.g. *see the penguin* rather than *the penguin see*. Other utterances contain modal verbs and nonfinite main verbs, and whenever both occur, the modal verb precedes the main verb, e.g. *could see* rather than *see could*. A child could be aware of the shared structure of these data – specifically that these observable forms can be characterized as the phrasal head appearing before its complements, as shown in (2).

(2) Shared structure in observable forms: Phrasal heads before complements

a. *see the penguin*



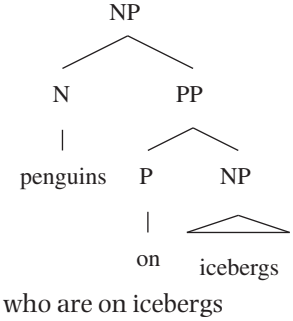
b. *could see*



This "head-first" idea can be encoded at a level that describes utterances in general, and would represent an overhypothesis about structure which is similar to the classical headedness linguistic macro-parameter: namely, phrases have their heads before their complements. Each example from (2) instantiates this overhypothesis for particular phrases, VPs and IPs, and so predicts the narrower hypotheses these data support: both VPs and IPs have their heads before their complements. Each narrower hypothesis strengthens the more abstract head-first overhypothesis, and allows the child to make predictions about phrases not yet encountered. For example, if this child encountered an utterance with a preposition surrounded by NPs, such as *penguins on icebergs*, there are (at least) two structural hypotheses possible, shown in (3).

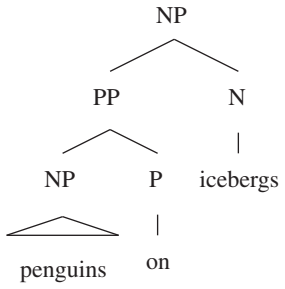
(3) Possible structures for *penguins on icebergs*

a. head-first:



Meaning: penguins who are on icebergs

b. head-last:



Meaning: icebergs that are on penguins

Using the head-first overhypothesis for both the NP and the PP, the child would prefer the structure in (3a), whose meaning indicates this phrase is about penguins who are on icebergs (rather than icebergs that are on penguins). Importantly, the child could have this head-first preference about NP and PP structure, even *without* having encountered a single NP or PP data point. This is the power of overhypotheses, and is the same powerful intuition that made the classical notion of linguistic macro-parameters attractive to developmental linguists. Children can learn how to make generalizations for data they've never seen before on the basis of the data they do see precisely because of the abstract system underlying the generation of the observable data.

In short, the classical notion of a linguistic macro-parameter is an abstract structural property that constrains the hypothesis space of the child, and is defined by UG. So, this type of parameter is an overhypothesis about the narrower structural hypotheses available. Bayesian inference can easily operate over hypothesis spaces that involve overhypotheses (and even more abstract levels – see Perfors et al. 2011b for a concrete example in the syntactic domain). Because of this, there may be a very intuitive connection between hierarchical Bayesian inference and acquisition with linguistic macro-parameters.

This connection in turn highlights the main strength of statistical learning that I mentioned in the introduction: statistical learning can help a child efficiently search a large hypothesis space. For instance, Bayesian inference can help a child efficiently search vast hypothesis spaces defined by overhypotheses and related narrower hypotheses; I discussed this above for linguistic macro-parameters, and it's also the approach taken by Pearl and Sprouse (in press) for linking theory acquisition.

What this then means is that children may not need their hypothesis spaces as constrained as we thought. That is, because children can harness statistical learning to more efficiently navigate a predefined hypothesis space, that hypothesis space could be larger or messier than we thought; this in turn may mean that we don't need as much specific innate knowledge to define children's hypothesis spaces as we thought. In other words, statistical learning could allow children to get away with hypothesis spaces that are more loosely defined – and yet children could still manage to successfully acquire their target linguistic knowledge.

So, statistical learning may either (i) replace language-specific knowledge that's meant to help a child navigate a predefined hypothesis space, or (ii) obviate the need for language-specific knowledge that constrains the child's hypothesis space so tightly.

Both of these results help us refine our ideas about what's in UG, and I'll discuss a concrete example of each below in Section 17.4.

An upshot of refining our ideas about what's in UG (in particular, reducing the amount of innate knowledge required – a goal at the heart of the Minimalist Program [Chomsky 2014]) is that we save ourselves some neurobiological explanatory work. In particular, everything that's part of UG must be present in a human's neurobiological endowment somehow. So, the more we build into UG, the more we have to explain about how that neurobiological endowment works. This generally involves explanations from both developmental neurobiology and evolutionary biology. So, it seems like a good idea to be very careful about what we propose to be in UG; if we consider the contributions of statistical learning in order to refine what's in UG, we may save ourselves some difficult explanatory work on the biological front.

17.3 When Statistical Learning Complements UG

I'll now briefly review the highlights of two recent studies (Pearl and Sprouse 2019, in press) that use statistical learning to investigate the acquisition of linking theories. (See Pearl (in press) for a more extensive review of both studies.) In each case, children's hypothesis space for linking theory knowledge is constrained by UG, and so statistical learning is operating over a linguistically predefined hypothesis space.

To get an idea about what linking theories are for, consider the following sentence: *The little girl blicked the kitten on the stairs.* Even if we don't know what *blick* means, we still have preferences about how to interpret this sentence. In particular, out of all the logically possible interpretations involving the little girl, the kitten, and the stairs, we prefer an interpretation where the little girl is doing something (blicking) to the kitten, and that event is happening on the stairs. The reason we as adults have this preferred interpretation is because we have *linking theories* that link the thematic roles specified by a verb's lexical semantics to the syntactic argument positions specified by that verb's syntactic frame. Moreover, our linking theories are so well-developed that they can impose these links even when we don't know a verb's specific lexical semantics (as we see here with *blick*). Developing linking theories is a fundamental component of verb learning for children.

There are two prominent options for linking theory theoretical representations: the Uniformity of Theta Assignment Hypothesis (**UTAH**) and the relativized form of that theory, relativized UTAH (**rUTAH**). The key difference between these two approaches has to do with how they deal with individual thematic roles. UTAH (Fillmore 1968; Perlmutter and Postal 1984; Jackendoff 1987; Baker 1988; Grimshaw 1990; Speas 1990; Dowty 1991; Baker 1997) groups these roles into larger thematic categories (like AGENT-ish, PATIENT-ish, or OTHER-ish) that then always map to a specific syntactic position (e.g. AGENT-ish ↔ *subject*). In contrast, rUTAH assumes there's a relative ordering of thematic roles (e.g. AGENT > PATIENT), and whichever thematic roles are present are sorted according to this ordering. Then, the highest role available maps to the highest syntactic position (e.g. *subject*). This gives rUTAH more flexibility than UTAH, for example allowing it to directly handle unaccusative constructions like *The ice*$_{\text{PATIENT}}$ *broke*. In this case, UTAH would expect the *subject* to have an AGENT-ish role, which

PATIENT certainly isn't. In contrast, rUTAH would note there was only one role available (PATIENT) and expect that role to appear in the highest syntactic position available (*subject*), which it does. Notably, both UTAH and rUTAH seem to be compatible with current cross-linguistic data, and so cross-linguistic coverage can't easily decide which one is likely to be the correct one.

There are also two main approaches to how children develop linking theory knowledge: (i) it's innate knowledge of the specific links between thematic roles and syntactic positions that comes fully formed in the child's mind (Fillmore 1968; Perlmutter and Postal 1984; Baker 1988; Larson 1990; Speas 1990; Grimshaw 1990), or (ii) the specific linking knowledge develops over time via an interplay between the input that children receive and the mechanisms (both statistical and otherwise) that underlie verb learning (Bowerman 1988; Goldberg 1995, 2006; Boyd and Goldberg 2011; Goldberg 2013). As with the theoretical representations, both developmental options seem viable at face value.

This is where models using linguistically savvy statistical learning may help. In particular, Pearl and Sprouse (in press) offer insight into the development of linking theory knowledge, suggesting that derivation of specific linking theory knowledge may occur over time from children's input. More specifically, their results argue against early maturation of innate linking theory knowledge. So, deriving that linking theory knowledge from the input becomes a plausible option to explore. An important takeaway from Pearl and Sprouse (in press) is that these results come from combining the statistical learning mechanism of hierarchical Bayesian inference with linguistic representations that define a child's hypothesis space (here, UTAH and rUTAH); by doing so, we gain insight about the process of acquisition that needs to accompany either linking theory representation.

Pearl and Sprouse (2019) offer insight into which theoretical option is more compatible with deriving linking theory knowledge from children's input. In particular, their results suggest two significant advantages for rUTAH over UTAH, if children derive their linking theories from their input using the Tolerance and Sufficiency Principles. First, a rUTAH-learning child will have a much easier time generating the complex linking patterns that comprise the rUTAH linking theory from the available input. Second, only rUTAH – and not UTAH – can be successfully generalized from English children's input using the Tolerance and Sufficiency Principles. So, by combining statistical learning with a linguistically defined hypothesis space, Pearl and Sprouse (2019) find support for a relativized linking theory like rUTAH over a fixed linking theory like UTAH, when coupled with a derivational theory of acquisition.

17.4 When Statistical Learning Refines What's in UG

We'll now turn to some examples where statistical learning can help refine our ideas of what's in UG. The first example demonstrates how statistical learning can replace a language-specific way to navigate a certain type of linguistic hypothesis space. The second example demonstrates how statistical learning can allow us to replace very specific UG syntactic knowledge with more general-purpose UG syntactic knowledge, and thereby lead to a hypothesis space that's less tightly constrained than previously thought.

17.4.1 A Bias for the Subset Hypothesis

One potential issue, known as the *Subset Problem* (Berwick 1985; Manzini and Wexler 1987), can arise when a child is navigating her hypothesis space. This problem occurs when the correct hypothesis for the language is a subset of a competing hypothesis for the language and the observed data are ambiguous between these hypotheses (see Figure 17.1). Here we see a two-dimensional space, where some data points are observed (each indicated with a *d*). All the observed data are compatible with both correct hypothesis C and incorrect hypothesis N.

The problem is that there are no data that can unambiguously indicate C is correct – every *d* in Figure 17.1 that can be accounted for by C can also be accounted for by N. Importantly, this isn't just an issue with the observed data in this particular scenario – it's a problem for C in general. There are no data a child could possibly encounter that would be compatible with C but not with N – this is what it means for C to be a subset of N (and for N to be a superset of C). So, because every data point in C is also in N, all "C" data points have unresolvable ambiguity between C and N (i.e. there's a Subset Problem caused by N if the child needs to learn C).

Importantly, this is a problem for the type of learning mechanisms that learning theorists previously assumed children used: mechanisms (i) relying on unambiguous data to trigger the correct hypothesis (Lightfoot 1989; Fodor 1998; Dresher 1999; Sakas and Fodor 2001, 2012), or (ii) involving error-driven learning that relies on some data being incompatible with the incorrect hypotheses (Gibson and Wexler 1994; Niyogi and Berwick 1996; Sakas and Fodor 2001). In our example, a child looking for data that unambiguously signal C won't find any – all data compatible with C are also compatible with N; a child looking for data that signal N is incorrect also won't find any – again, all data she'll encounter (which come from speakers using C) will be compatible with N, too.

To tackle this problem, the Subset Principle (Berwick 1985; Manzini and Wexler 1987) was proposed; this principle causes the child to prefer the subset hypothesis, even if the data are ambiguous (e.g. preferring C over N, despite all the *d*s being compatible with both hypotheses). This principle was language-specific (and so part of UG), and intended to help children successfully navigate linguistic hypothesis spaces that had these subset problems.

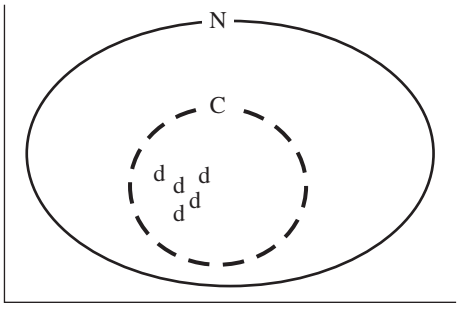


Figure 17.1 A visual demonstration of the Subset Problem: a two-dimensional hypothesis space where one hypothesis (the correct one, C, in dashed lines) is a subset of a competing hypothesis (an incorrect one, N). Each d corresponds to an observed data point, and both hypotheses are compatible with the observed data.

However, this same preference can be derived from the mechanics of Bayesian inference, which doesn't have to be built into UG. Recall the two components used to calculate the posterior probabilities of different hypotheses: the prior of a hypothesis, $P(h)$, and the likelihood of the data, given a hypothesis, $P(D|h)$. The prior captures how much the child favors the hypothesis before any data have been encountered. Let's suppose that the priors for both C and N are the same (say, $P(C) = P(N) = 0.5$), so there's no reason to prefer one over the other a priori.

The likelihood can be calculated by considering the probability of a particular hypothesis generating the observed data. This is where children's expectations about the data each hypothesis could generate are really important. In particular, because C is a subset of N, C is by definition capable of generating fewer data than N is. To be concrete, let's suppose C is capable of generating 10 data points (including the 5 we saw in Figure 17.1) while N is capable of generating 20 data points (including the 10 that C can generate, which include the 5 we saw in Figure 17.1), as shown in Figure 17.2.

Let's now consider the probability of each hypothesis generating a data point like d_1, which is compatible with both C and N. Because C can generate 10 data points, the probability of C generating d_1 is $\frac{1}{10}$ ($P(d_1|C) = 0.10$). Because N can generate 20 data points, the probability of N generating d_1 is $\frac{1}{20}$ ($P(d_1|N) = 0.05$).

Because the posterior probabilities of C and N, given the data, are proportional to their prior * likelihood, this means that a child seeing only ambiguous data point d_1 would assess the posterior probabilities of C and N as in (4):

(4) a. $P(C|d_1) \propto P(C) * P(d_1|C) = 0.5 * 0.1 = 0.05$
b. $P(N|d_1) \propto P(N) * P(d_1|N) = 0.5 * 0.05 = 0.025$

So, just from seeing d_1, a child would believe correct subset hypothesis C is twice as likely as incorrect superset hypothesis N ($\frac{P(C|d_1)}{P(N|d_1)} = \frac{0.05}{0.025} = 2$). That is, the child has a preference for the subset hypothesis C, even without having encountered either unambiguous data for C or error data indicating N is incorrect. This is exactly what the Subset Principle was meant to instill.

Moreover, the more data the child sees like d_1 (i.e., compatible with both the subset and superset hypotheses), the stronger this preference becomes. For instance, if the child saw 5 data points compatible with both C and N (i.e., $\{d_1, d_2, d_3, d_4, d_5\} = Data$, as in

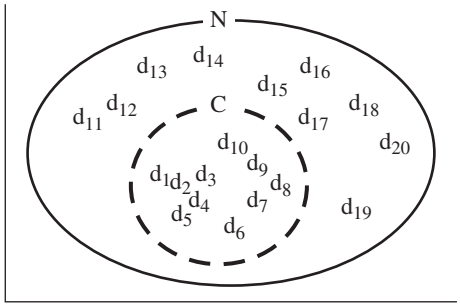


Figure 17.2 A visual demonstration of the data each hypothesis (correct subset hypothesis C and incorrect superset hypothesis N) can generate.

Figure 17.1), the likelihood for C would be $(\frac{1}{10})^5 = 0.00001$, while the likelihood for N would be $(\frac{1}{20})^5 = 0.0000003125$. Because the priors for C and N are still the same (0.5), these ambiguous data would cause the child to believe correct subset hypothesis C is 32 times more likely than incorrect superset hypothesis N ($\frac{P(C|Data)}{P(N|Data)} = \frac{0.5*0.00001}{0.5*0.0000003125} = 32$). This is an even stronger bias for the subset. Notably, Bayesian inference allows us to quantify how much the child ought to prefer the subset hypothesis, given the data encountered; this is in contrast to the Subset Principle, which specifies that the child ought to prefer the subset hypothesis, but not *how much* she ought to prefer it.

More generally, this example is meant to highlight how statistical learning (in this case, Bayesian inference) can offer an alternative solution for navigating a tricky language learning scenario (i.e. when the linguistic hypotheses overlap in a particular way and all the available data are ambiguous). So, a child could successfully navigate this linguistic hypothesis space without relying on a language-specific mechanism to do so; instead, Bayesian inference would allow her the same navigation ability and also not require us to build that navigation mechanism into UG.

17.4.2 Linguistic Knowledge for Syntactic Islands

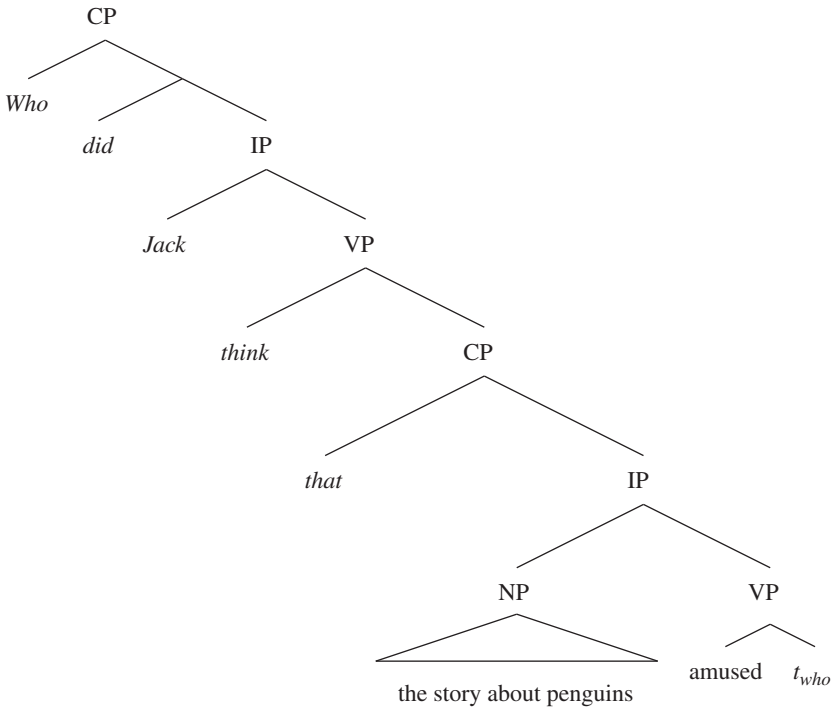
Relationships between two words in a sentence that aren't adjacent to each other, such as the long-distance dependency between *what* and *stole* in (5), can be potentially infinite in length. However, there are specific syntactic structures that long-distance dependencies can't cross, known as *syntactic islands*, with four examples shown in (5b)-(5e) (Chomsky 1965; Ross 1967; Chomsky 1973). During acquisition, children must infer the constraints on long-distance dependencies (i.e. the syntactic islands) that allow them to recognize that the *wh*-dependencies in (5b)-(5e) aren't allowed, while the *wh*-dependency in (5) is.

(5) a. What does Jack think that Lily said that the goblins stole t_{what}?
b. *whether* island
*What do you wonder [whether Jack bought t_{what}]?
c. complex NP island
*What did you make [the claim that Jack bought t_{what}]?
d. subject island
*What do you think [the joke about t_{what}] was hilarious?
e. adjunct island
*What do you worry [if Jack buys t_{what}]?

Pearl and Sprouse (2013b,a, 2015) investigated a statistical learning strategy for learning about syntactic islands that probabilistically leveraged linguistic knowledge; more specifically, this strategy relied on children characterizing a long-distance dependency as a path from the head of the dependency (e.g., *Who* in (6)) through the phrasal nodes that contain the tail of the dependency, as shown in (6a)-(6b). Under this view, children simply need to learn which long-distance dependencies have licit syntactic paths and which don't. The probabilistic learning strategy of Pearl and Sprouse tracks local pieces of these syntactic paths, which we can think of as the building blocks of the syntactic paths. Here, I'll briefly review the highlights of how we can interpret the results of this linguistically savvy statistical learning strategy, but see Pearl (in press) for a more detailed overview of both the strategy itself and how to interpret it.

(6) Who did Jack think that the story about penguins amused t_{who}?

a. Phrasal node structure containing the *wh*-dependency:



Who did [$_{IP}$ Jack [$_{VP}$ think [$_{CP}$ that [$_{IP}$ the story about penguins [$_{VP}$ amused t_{who}]]]]]?

b. Syntactic path of *wh*-dependency:
start-IP-VP-CP$_{that}$-IP-VP-*end*

Pearl and Sprouse's results suggested that their proposed learning strategy was a reasonable way for English children to acquire knowledge of the four islands in (5b)-(5e). Importantly, this strategy offers an alternative to a previous acquisition theory for syntactic islands from the Government and Binding framework of the 1980s, which involved a constraint called the *Subjacency Condition*. This constraint basically says that dependencies can't cross two or more *bounding nodes* (Chomsky 1973; Huang 1982; Lasnik and Saito 1984, among others); if a dependency crosses two or more bounding nodes, a syntactic island occurs. What counts as a bounding node varies cross-linguistically, though bounding nodes are always drawn from the set {NP, IP, CP}. So, when using this representation, children needed to learn which of these are bounding nodes in their language, though they already know (via UG) about the two-bounding-node restriction and the set of possible bounding nodes. That is, children's hypothesis space is highly restricted.

The learning strategy of Pearl and Sprouse (2013b,a, 2015) shares the intuition with subjacency that there's a local structural anomaly when syntactic islands occur. However, instead of characterizing this anomaly with bounding nodes, Pearl and Sprouse suggested that it could be described as a low-probability region with respect to the phrase

structure nodes that characterize the syntactic path of the *wh*-dependency. There's no need for the child to know about a hard constraint prohibiting the crossing of two bounding nodes, and in fact no need for the child to identify bounding nodes at all. Instead, children would need to identify the phrase structure nodes containing the *wh*-dependency and break that syntactic path into smaller building blocks based on phrase structure nodes – certainly no trivial matter, but one that involves building blocks that are more general-purpose than bounding nodes.

And this is the point: the knowledge of building blocks based on phrase structure nodes and how to use them doesn't require children to have a highly constrained hypothesis space defined in terms of UG-specified bounding nodes. That is, because children could use statistical learning to navigate a hypothesis space comprised of syntactic path building blocks, their linguistic hypothesis space doesn't have to be as constrained by UG as the original Subjacency approach assumed it was.

17.5 Concluding Thoughts

I hope to have shown here how statistical learning can play well with UG, by both complementing and refining our ideas about UG. Statistical learning requires a predefined hypothesis space to operate over, and that's precisely what UG can provide. Statistical learning can then allow efficient navigation of that hypothesis space, and so perhaps reduce the built-in knowledge required to define that hypothesis space in the first place. This is why I believe researchers who like the idea of UG should be interested in incorporating statistical learning into their theories of language acquisition. Of course, there's much work to be done if we continue down this avenue. We need to provide concrete, testable theories of how acquisition could proceed using both statistical learning and whatever innate linguistic knowledge we think may be appropriate (e.g., see Pearl (2014, in press) for specific examples of how to do this with mathematical and computational developmental modeling). By doing so, we can see how statistical learning can allow children to get far more mileage out of the innate, language-specific knowledge we believe is in UG.

Endnote

1 In the interest of space, I'll only provide abbreviated descriptions of each statistical learning mechanism, but see Pearl (in press) for a more comprehensive overview of each one.

References

Abend Omri, Tom Kwiatkowski, Nathaniel J Smith, Sharon Goldwater, and Mark Steedman. 2017. Bootstrapping language acquisition. *Cognition* 164: 116–143.

Aslin Richard N. 2017. Statistical learning: A powerful mechanism that operates by mere exposure. *Wiley Interdisciplinary Reviews: Cognitive Science* 8(1-2): e1373.

Aslin Richard N, Jenny R Saffran, and Elissa L Newport. 1998. Computation of conditional probability statistics by 8-month-old infants. *Psychological Science* 9(4): 321–324.

Baker Mark C. 1988. *Incorporation: A theory of grammatical function changing*. Chicago, IL: University of Chicago Press.

Baker Mark C. 1997. Thematic roles and syntactic structure. In *Elements of grammar*, pages 73–137. New York: Springer.

Misha Becker. 2014. *The acquisition of syntactic structure: Animacy and thematic alignment*, volume 141. Cambridge University Press.

Berwick Robert C. 1985. *The acquisition of syntactic knowledge*, volume 16. Cambridge, MA: MIT press.

Melissa Bowerman. 1988. The "No Negative Evidence" problem: How do children avoid constructing an overly general grammar? In J. Hawkins, editor, *Explaining language universals*, pages 73–101. Oxford, England: Blackwell.

Jeremy Boyd and Adele Goldberg. 2011. Learning what not to say: The role of statistical preemption and categorization in a-adjective production. *Language* 87(1): 55–83.

Bush Robert R and Frederick Mosteller. 1951. A model for stimulus generalization and discrimination. *Psychological Review* 58(6): 413.

Noam Chomsky. 1965. *Aspects of the Theory of Syntax*. Cambridge: The MIT Press.

Chomsky Noam. 1973. Conditions on transformations. In S. Anderson and P. Kiparsky, editors, *A Festschrift for Morris Halle*, pages 237–286. New York: Holt, Rinehart, and Winston.

Chomsky Noam. 1975. *Reflections on language*. New York: Pantheon Books.

Chomsky Noam. 1980a. Rules and representations. *Behavioral and Brain Sciences* 3: 1–61.

Chomsky Noam. 1980b. *Rules and Representations*. Oxford: Basil Blackwell.

Chomsky Noam. 1981. *Lectures on Government and Binding*. Dordrecht: Foris.

Chomsky Noam. 1986. *Barriers*, volume 13. Cambridge: MIT press.

Chomsky Noam. 2014. *The Minimalist Program*. Cambridge: MIT press.

Crain Stephen and Paul Pietroski. 2002. Why language acquisition is a snap. *The Linguistic Review* 19: 163–183.

Minto de Sousa Naiara, Lucas Tadeu Garcia, and Maria Stella Coutinho de Alcantara Gil. 2015. Differential reinforcement in simple discrimination learning in 10-to 20-month-old toddlers. *The Psychological Record* 65(1): 31–40.

Denison Stephanie, Christie Reed, and Fei Xu. 2011. The emergence of probabilistic reasoning in very young infants. In *Proceedings of the Annual Meeting of the Cognitive Science Society*, volume 33.

Dewar Kathryn M and Fei Xu. 2010. Induction, overhypothesis, and the origin of abstract knowledge: Evidence from 9-month-old infants. *Psychological Science* 21(12): 1871–1877.

Dowty David. 1991. Thematic proto-roles and argument selection. *Language* pages 547–619.

Elan Dresher B.. 1999. Charting the learning path: Cues to parameter setting. *Linguistic Inquiry* 30(1): 27–67.

Feldman Naomi, Thomas Griffiths, Sharon Goldwater, and James Morgan. 2013. A role for the developing lexicon in phonetic category acquisition. *Psychological Review* 120(4): 751–778.

Ferry Alissa L, Ana Fló, Perrine Brusini, Luigi Cattarossi, Francesco Macagno, Marina Nespor, and Jacques Mehler. 2016. On the edge of language acquisition: Inherent constraints on encoding multisyllabic sequences in the neonate brain. *Developmental Science* 19(3): 488–503.

Fillmore Charles J. 1968. The case for case. In E. Bach and R. Harms, editors, *Universals in Linguistic Theory*. New York: Holt, Rinehart, & Winston, Inc.

Fiser József and Richard N Aslin. 2002. Statistical learning of new visual feature combinations by infants. *Proceedings of the National Academy of Sciences* 99(24): 15822–15826.

Fló Ana, Perrine Brusini, Francesco Macagno, Marina Nespor, Jacques Mehler, and Alissa L Ferry. 2019. Newborns are sensitive to multiple cues for word segmentation in continuous speech. *Developmental Science* page e12802.

Fodor Janet D.. 1998. Unambiguous Triggers. *Linguistic Inquiry* 29: 1–36.

Freudenthal Daniel, Julian M Pine, Javier Aguado-Orea, and Fernand Gobet. 2007. Modeling the developmental patterning of finiteness marking in English, Dutch, German, and Spanish using MOSAIC. *Cognitive Science* 31(2): 311–341.

Freudenthal Daniel, Julian M Pine, and Fernand Gobet. 2009. Simulating the referential properties of Dutch, German, and English root infinitives in MOSAIC. *Language Learning and Development* 5(1): 1–29.

Freudenthal Daniel, Julian Pine, and Fernand Gobet. 2010. Explaining quantitative variation in the rate of Optional Infinitive errors across languages: a comparison of MOSAIC and the Variational Learning Model. *Journal of Child Language* 37(03): 643–669.

Freudenthal Daniel, Julian M Pine, Gary Jones, and Fernand Gobet. 2015. Defaulting effects contribute to the simulation of cross-linguistic differences in Optional Infinitive errors. In *Proceedings of the 37th Annual Meeting of the Cognitive Science Society*, pages 746–751, Pasadena.

Gerken LouAnn. 2006. Decisions, decisions: Infant language learning when multiple generalizations are possible. *Cognition* 98(3): B67–B74.

Gerken LouAnn. 2010. Infants use rational decision criteria for choosing among models of their input. *Cognition* 115(2): 362–366.

Gibson Edward and Kenneth Wexler. 1994. Triggers. *Linguistic Inquiry* 25(4): 407–454.

Goldberg Adele E. 1995. *Constructions: A Construction Grammar Approach to Argument Structure*. University of Chicago Press.

Goldberg Adele E. 2006. *Constructions at Work: The Nature of Generalization in Language*. Oxford University Press on Demand.

Goldberg Adele E. 2013. Argument structure constructions versus lexical rules or derivational verb templates. *Mind & Language* 28(4): 435–465.

Goodman Nelson. 1955. *Fact, fiction and forecast*, volume 74. JSTOR.

Grimshaw Jane. 1990. *Argument Structure*. Cambridge: The MIT Press.

James Huang C.-T.. 1982. *Logical Relations in Chinese and the Theory of Grammar*. PhD thesis, Cambridge: MIT Press.

Hulsebus Robert C. 1974. Operant conditioning of infant behavior: A review. In *Advances in Child Development and Behavior*, volume 8, pages 111–158. Elsevier.

Irani Ava. 2019. How Children Learn to Disappear Causative Errors. In Megan M. Brown and Brady Dailey, editors, *Proceedings of the 43rd Boston University Conference on Language Development*, pages 298–310. Somerville, MA: Cascadilla Press.

Jackendoff Ray. 1987. The status of thematic relations in linguistic theory. *Linguistic inquiry* 18(3): 369–411.

Jackendoff Ray S. 1994. *Patterns in the Mind: Language and Human Nature*. New York: Basic Books.

Kemp Charles and Joshua B Tenenbaum. 2008. The discovery of structural form. *Proceedings of the National Academy of Sciences* 105(31): 10687–10692.

Kemp Charles, Amy Perfors, and Joshua Tenenbaum. 2007. Learning overhypotheses with hierarchical bayesian models. *Developmental Science* 10(3): 307–321.

Kirkham Natasha Z, Jonathan A Slemmer, and Scott P Johnson. 2002. Visual statistical learning in infancy: Evidence for a domain general learning mechanism. *Cognition* 83(2): B35–B42.

Larson Richard K. 1990. Double objects revisited: Reply to Jackendoff. *Linguistic Inquiry* 21(4): 589–632.

Lasnik Howard and Mamuro Saito. 1984. On the nature of proper government. *Linguistic Inquiry* 15: 235–289.

Laurence Stephen and Eric Margolis. 2001. The poverty of the stimulus argument. *The British Journal for the Philosophy of Science* 52(2): 217–276.

Legate Julie and Charles Yang. 2007. Morphosyntactic Learning and the Development of Tense. *Linguistic Acquisition* 14(3): 315–344.

Legate Julie and Charles Yang. 2013. Assessing Child and Adult Grammar. In Robert Berwick and Massimo Piatelli-Palmarini, editors, *Rich Languages from Poor Inputs*, pages 168–182. Oxford, UK: Oxford University Press.

Lightfoot David. 1989. The child's trigger experience: degree-0 learnability. *Behavioral and Brain Sciences* 12: 321–334.

Lipsitt Lewis P, Linda Johnson Pederson, and Clement A Delucia. 1966. Conjugate reinforcement of operant responding in infants. *Psychonomic Science* 4(1): 67–68.

Manzini M and K Wexler. 1987. Parameters, binding theory, and learnability. *Linguistic Inquiry* 18: 413–444.

Garrett Mitchener William and Misha Becker. 2010. Computational models of learning the raising-control distinction. *Research on Language and Computation* 8(2-3): 169–207.

Niyogi Partha and Robert C. Berwick. 1996. A language learning model or finite parameter spaces. *Cognition* 61: 161–193.

Orita Naho, Rebecca McKeown, Naomi H Feldman, Jeffrey Lidz, and Jordan Boyd-Graber. 2013. Discovering pronoun categories using discourse information. In *Proceedings of the 35th Annual Conference of the Cognitive Science Society*.

Pearl Lisa. 2014. Evaluating learning strategy components: Being fair. *Language* 90 (3): e107–e114.

Pearl Lisa. 2019. Poverty of the stimulus without tears. Irvine: University of California. URL https://ling.auf.net/lingbuzz/004646.

Pearl Lisa. in press. Modeling syntactic acquisition. In Jon Sprouse, editor, *Oxford Handbook of Experimental Syntax*. Oxford University Press.

Pearl Lisa and Jeffrey Lidz. 2013. Parameters in Language Acquisition. In Kleanthes Grohmann and Cedric Boeckx, editors, *The Cambridge Handbook of Biolinguistics*, pages 129–159. Cambridge, UK: Cambridge University Press.

Pearl Lisa and Benjamin Mis. 2016. The role of indirect positive evidence in syntactic acquisition: A look at anaphoric one. *Language* 92(1): 1–30.

Pearl Lisa and Jon Sprouse. 2013a. Syntactic islands and learning biases: Combining experimental syntax and computational modeling to investigate the language acquisition problem. *Language Acquisition* 20: 19–64.

Pearl Lisa and Jon Sprouse. 2013b. Computational Models of Acquisition for Islands. In Jon Sprouse and Norbert Hornstein, editors, *Experimental Syntax and Islands Effects*, pages 109–131. Cambridge: Cambridge University Press.

Pearl Lisa and Jon Sprouse. 2015. Computational modeling for language acquisition: A tutorial with syntactic islands. *Journal of Speech, Language, and Hearing Research* 58: 740–753.

Pearl Lisa and Jon Sprouse. 2019. The acquisition of linking theories: A Tolerance and Sufficiency Principle approach to learning UTAH and rUTAH. URL https://ling.auf.net/lingbuzz/004088.

Pearl Lisa and Jon Sprouse. in press. Comparing solutions to the linking problem using an integrated quantitative framework of language acquisition. *Language* URL https://ling.auf.net/lingbuzz/003913.

Pearl Lisa, Kristine Lu, and Anousheh Haghighi. 2017. The character in the letter: Epistolary attribution in Samuel Richardson's *Clarissa*. *Digital Scholarship in the Humanities* 32(2): 355–376.

Perfors Amy, Joshua Tenenbaum, and Elizabeth Wonnacott. 2010. Variability, negative evidence, and the acquisition of verb argument constructions. *Journal of Child Language* 37(3): 607 –642.

Perfors Amy, Joshua Tenenbaum, Thomas Griffiths, and Fei Xu. 2011a. A tutorial introduction ot bayesian models of cognitive development. *Cognition* 120(3): 302–321.

Perfors Amy, Joshua Tenenbaum, and Terry Regier. 2011b. The learnability of abstract syntactic principles. *Cognition* 118: 306–338.

Perlmutter David M and Paul M Postal. 1984. Impersonal passives and some relational laws. *Studies in Relational Grammar* 2: 126–170.

Piantadosi Steven, Joshua Tenenbaum, and Noah Goodman. 2012. Bootstrapping in a language of thought: A formal model of numerical concept learning. *Cognition* 123(2): 199–217.

Ross John. 1967. *Constraints on variables in syntax*. PhD thesis, Cambridge, MA: MIT.

Kent Rovee Carolyn and David T Rovee. 1969. Conjugate reinforcement of infant exploratory behavior. *Journal of Experimental Child Psychology* 8(1): 33–39.

Kent Rovee-Collier Carolyn and Joanne Bitetti Capatides. 1979. Positive behavioral contrast in 3-month-old infants on multiple conjugate reinforcement schedules. *Journal of the Experimental Analysis of Behavior* 32(1): 15–27.

Saffran Jenny R, Richard N Aslin, and Elissa L Newport. 1996. Statistical learning by 8-month-old infants. *Science* 274(5294): 1926–1928.

Saffran Jenny R, Elizabeth K Johnson, Richard N Aslin, and Elissa L Newport. 1999. Statistical learning of tone sequences by human infants and adults. *Cognition* 70(1): 27–52.

Sakas William. 2016. Computational approaches to parameter setting in generative linguistics. In Jeffrey Lidz, William Snyder, and Joe Pater, editors, *The Oxford Handbook of Developmental Linguistics*, pages 696–724. Oxford, UK: Oxford University Press.

Sakas William and Janet Fodor. 2012. Disambiguating Syntactic Triggers. *Language Acquisition* 19(2): 83–143.

Sakas William and Janet D. Fodor. 2001. The Structural Triggers Learner. In Stefano Bertolo, editor, *Language Acquisition and Learnability*, pages 172–233. Cambridge, UK: Cambridge University Press.

Scholz Barbara and Geoffrey Pullum. 2006. Irrational nativist exuberance. In Robert Stainton, editor, *Contemporary Debates in Cognitive Science*.

Schuler Kathryn, Charles Yang, and Elissa Newport. 2016. Testing the Tolerance Principle: Children form productive rules when it is more computationally efficient to do so. In *The 38th Cognitive Society Annual Meeting, Philadelphia, PA*.

Speas Margaret. 1990. *Phrase Structure in Natural Language*, volume 21. Springer Science & Business Media.

Stahl Aimee E, Alexa R Romberg, Sarah Roseberry, Roberta Michnick Golinkoff, and Kathryn Hirsh-Pasek. 2014. Infants segment continuous events using transitional probabilities. *Child Development* 85(5): 1821–1826.

Sutton Richard S and Andrew G Barto. 2018. *Reinforcement Learning: An Introduction*. Cambridge: MIT press.

Watson John S. 1969. Operant conditioning of visual fixation in infants under visual and auditory reinforcement. *Developmental Psychology* 1(5): 508.

Wu Rachel, Alison Gopnik, Daniel C Richardson, and Natasha Z Kirkham. 2011. Infants learn about objects from statistics and people. *Developmental Psychology* 47(5): 1220.

Xu Fei and Joshua Tenenbaum. 2007. Word Learning as Bayesian Inference. *Psychological Review* 114(2): 245–272.

Yang Charles. 2002. *Knowledge and Learning in Natural Language*. Oxford, UK: Oxford University Press.

Yang Charles. 2004. Universal grammar, statistics or both? *Trends in Cognitive Science* 8(10): 451–456.

Yang Charles. 2005. On productivity. *Yearbook of Language Variation* 5: 333–370.

Yang Charles. 2012. Computational models of syntactic acquisition. *WIREs Cognitive Science* 3: 205–213.

Yang Charles. 2015. Negative knowledge from positive evidence. *Language* 91(4): 938–953.

Yang Charles. 2016. *The Price of Linguistic Productivity: How Children Learn to Break the Rules of Language*. Cambridge: MIT Press.

Yang Charles. 2017. How to wake up irregular (and speechless). *On looking into Words (and beyond)*, pages 211–233.

18

Chomsky and Usage-Based Linguistics[1]

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"Grammars code best what speakers do most." (Du Bois 1985, p. 363)
"Language is poorly designed for communication […]" (Chomsky 2012, p. 50)

18.1 Introduction

Noam Chomsky, in the course of his long career, has attracted at least as many opponents as he has attracted supporters. While many diverse objections have been raised to his theoretical outlook, the most prominent is that he has always slighted the study of the *use* of language in favor of the study of *knowledge* of language and, in particular, that he fails to appreciate the degree to which the latter is beholden to the former. Those who take this position, however much they might disagree with each other, are known as "usage-based linguists." This chapter attempts to unravel the differences, whether real or merely apparent, between Chomsky's linguistics and usage-based linguistics. It is organized as follows. Section 18.2.1 outlines the basic tenets of usage-based linguistics, while Section 18.2.2 contrasts usage-based linguistics with functional linguistics, designations that are synonyms for some, but not for others. The brief Section 18.3 discusses the few direct references Chomsky has made to usage-based linguistics. The much longer Section 18.4 takes up the most important contrasts between Chomsky's work and those of his usage-based opponents. Section 18.5 concludes the chapter.

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18.2 Usage-Based Linguistics

The principal alternative to generative grammar in the world today is a broad umbrella of approaches that fall under the general heading of usage-based linguistics (UBL). Within UBL there is far more diversity of opinion than within generative grammar, and hence, many assertions about UBL in this chapter will not be accepted by all usage-based linguists (UBLists). But what all varieties of UBL have in common is the idea that there exists a much more intimate connection between language knowledge and language use than is recognized by Chomsky and other generative grammarians. In the words of Joan Bybee, an important UBList: "While all linguists are likely to agree that grammar is the cognitive organization of language, a usage-based theorist would make the more specific proposal that grammar is the cognitive organization of one's *experience* with language" (Bybee 2006, p. 711; my emphasis).

A certain number of UBLists identify with particular named frameworks, among which are Cognitive Linguistics, one of whose subsidiary approaches is Cognitive Grammar (Taylor 2010)[2], Cognitive Construction Grammar (Goldberg 2006), Radical Construction Grammar (Croft 2001), Embodied Construction Grammar (Feldman, Dodge, and Bryant 2010), Word Grammar (Hudson 2007), Frame-Semantic Construction Grammar (Boas 2013), Functional Discourse Grammar (Hengeveld and Mackenzie 2008), Role and Reference Grammar (Van Valin and LaPolla 1997), Systemic Functional Linguistics (Halliday and Matthiessen 2014), Interactional Linguistics, itself a successor to Emergent Grammar (Bybee 2010), Columbia School Linguistics (Davis, Gorup, and Stern 2006), Collostructional Analysis (Stefanowitsch 2013), and the Lexical Constructional Model (Ruiz de Mendoza Ibáñez and Galera Masegosa 2014).[3] However, my impression is that a solid majority of UBLists identify with no named framework at all. A nonexhaustive list of some of the more prominent UBLists who fall into this category are Sonia Cristofaro, Matthew Dryer, Eve Clark, Nicholas Evans, Talmy Givón, Martin Haspelmath, Bernd Heine, John A. Hawkins, Tania Kuteva, Stephen Levinson, Edith Moravcsik, Martin Lemmens, Michael Tomasello, and Elizabeth Traugott.

Another impression that I have is that on a world scale, there are far more UBLists than generative grammarians. By way of support, the International Cognitive Linguistics Association, when it meets in Europe, outdraws its generative counterpart, Generative Linguists of the Old World, by a factor of two or three to one. As Henk van Riemsdijk, the doyen of Dutch generative linguistics, has observed:

> Take a country like Germany. It is not a poor country, they've got a lot of universities. But if you want to pin point the centers of generative grammar, depending on your generosity, you end up with maybe half of a dozen. (Riemsdijk 1998, p. 18)

While many German linguists work in formal semantics, which is not usage-based, the majority practice one or another version of UBL. The same appears to be true in France and Italy.

18.2.1 Some Tenets of Usage-Based Linguistics

This section outlines the principal claims of UBL. It is intentionally light on citations and specifics, which are provided in Section 18.4, where the differences between Chomsky and UBLists are elaborated in some detail.

A hallmark of UBL is the intimate relationship between usage and structure, to the point where the competence-performance distinction is either rejected or greatly downplayed. As an alternative, UBL emphasizes the *emergence* (a frequently used term) of grammatical structure from the process of communication. A central idea is that since the primary function of language is to convey meaning, it stands to reason that one would look for an explanation of why language is the way it is in terms of what kind of system would be best designed to carry out this task. Most versions of UBL consider any boundary between semantics and pragmatics as wholly artificial from a communicative point of view and, above all, reject model-theoretic accounts of meaning, which are seen as obfuscating the role of the language user in creating meaning. The nature of meaning in UBL is quite complex (as well as varying greatly from approach to approach), but it tends to be intimately linked to conceptualizations which have an experiential basis, and which incorporate imagery, metaphor, and, in general, the ways that human beings experience reality, both culturally and physiologically. Meanings and the structures that they shape are not divided into discrete categories, but rather have a best case (exemplar) and less central manifestations, a circumstance that has a direct reflex in grammatical structure.

UBL hypothesizes that the boundaries between properties of language and those of other cognitive domains are not sharp and hence that there are few if any innately provided specifically linguistic constructs. In other words, UBL is the successor to a Piagetian approach to language acquisition, where experience and general learning principles shape the acquisition process. UBLists question the idea of the modularity of grammatical architecture, which to one degree or another has been a hallmark of generative grammar. As suggested in the previous paragraph, many (but not all) UBLists reject the Saussurean idea that grammar (form and meaning taken together) is characterizable in terms of an independent cognitive module. However, all reject the Chomskyan idea of the autonomy of syntax. Grammatical models tend to be construction-based, that is, incorporating schema in which grammatical structures are directly linked to their meanings, where *meaning* is interpreted in the broadest sense possible.

The importance of "frequency of use" is at the center of all usage-based approaches. Frequency shapes language change, as more frequently used forms are grammaticalized more often than less frequently used forms, it shapes syntactic structure, as exemplars (and their effects in the structure of constructions) are byproducts of frequency of use, and it shapes phonological structure, as there is more phonological reduction in high frequency phrases, which itself has consequences for phonological change.

While UBL does not reject introspectively derived data outright, it stresses the importance of corpora (in particular, conversational corpora) as the best source of data for constructing a linguistic theory. In the view of most UBLists, the highly abstract structures of most models of generative grammar are an unfortunate and unnatural consequence of basing theoretical conclusions on artificial and rarely used sentences that the investigator makes up out of his or her head.

18.2.2 Usage-Based Linguistics and Functional Linguistics

More and more linguists who at one time called themselves "functional linguists" or "functionalists" now refer to themselves as "usage-based linguists." What, then, is the difference between functional linguistics and UBL and why the change in self-designation? The answer is complex. Functional linguistics (or functionalism) was

for many years considered to be the main rival to formal linguistics (i.e. generative grammar). Functionalism takes the position that properties of grammatical systems are explicable in terms of properties of systems that lie outside of grammar per se. In other words, functionalists advocate external explanation, as opposed to the internal explanation of generative grammar. So a functionalist might appeal to pressure for an iconic relationship between form and meaning to explain why grammatical constituents tend to line up with semantic constructs, to pressure for parsing efficiency to explain why "heavy" constituents in VO languages tend to occur in extraposed position, or to pressure for communicative efficiency to explain why topic elements tend to occur before comment elements. As one can deduce from what is written in Section 18.2.1, all of the above is fully compatible with UBL.

There are several reasons why the term *usage-based linguistics* has come largely to replace the term *functional linguistics*. First, it is broader in the appropriate way. The framework of Cognitive Grammar, for example, has not generally been concerned with most forms of external explanation, though it is user-based according to the characterization of UBL in Section 18.2.1. Second, the term *UBL* is less ambiguous than the term *functional linguistics*. Linguists like Susumu Kuno and Ellen Prince, for example, are known for their studies of the (communicative) functions of grammatical forms and are often therefore (confusingly) referred to as functionalists (for typical work, see Kuno 1987 and Prince 1988). However, they have adopted few of the principal features of UBL, a fact which excludes them from consideration as UBLists. Indeed, Kuno has written that "in theory, there is no conflict between [his version of – FJN] functional syntax and, say, the revised extended standard theory of generative grammar" (Kuno 1980, p. 117). Third, the term *functionalist* has a long-standing use (primarily in Europe) centring on the study of the interactional functioning of elements internal to the grammar (Martinet 1962). This work might reasonably be considered "functionalist," but is not necessarily usage-based. The same could be said for an account that appeals to a cognitive preference for symmetric systems or for particular patterns. Such accounts would technically be functionalist (where the functions are cognitive rather than communicative), but not usage-based. Finally, an account can be usage-based, without being functionalist, as is the case with a Labovian-style variable-rule approach that brings into the analysis statistical facts about usage, without presenting a functional explanation for these facts (e.g. Cedergren and Sankoff 1974).

It is important to bear in mind that there are still many linguists who use the terms *user-based* and *functionalist* interchangeably, a fact that can be very confusing to those with casual knowledge of this area of linguistics. In the remainder of this chapter, I do my utmost to avoid ambiguity of usage.

18.3 Chomsky and Usage-Based Linguistics: The Short Story

The fact is that Chomsky has very rarely directly critiqued published work in UBL. In Chomsky (2009, p. 392) we find a refutation of the connectionist account of the representation of nested dependencies in Elman (1991). Berwick, Pietroski, Yankama, and Chomsky (2011) take on attempted refutations of poverty of the stimulus-based arguments in support of universal grammar in such work as Reali and Christiansen (2005) and Clark and Eyraud (2007). In Berwick and Chomsky (2016, pp. 39, 97)

there are fleeting references to the work of Michael Tomasello (Tomasello 2009) on "general principles of learning" and a short passage in Chomsky (2016, 6) criticizes Dedieu and Levinson (2013) for their overly broad definition of language. If Chomsky has critiqued (or even referred to) any other work in UBL related to grammatical theory or analysis, I am not aware of it. Of the linguists mentioned previously in Section 18.2, he cites only Tomasello and Levinson and he never refers at all to other leading UBLists like Joan Bybee, Bernard Comrie, William Croft, Nicholas Evans, Adele Goldberg, Martin Haspelmath, Kees Hengeveld, Paul Hopper, Randy LaPolla, George Lakoff (in his post-generative semantics period), Ronald Langacker, Brian MacWhinney, Sandra Thompson, or Robert Van Valin.

One sometimes gets the feeling that Chomsky *intentionally avoids* referring to his usage-based opponents by name. His work abounds with indirect references to their work, but without citing particular names or publications, as in Chomsky (1980, pp. 214–215, 229; 2004a, p. 55; 2005, p. 2; 2012, p. 15; 2016, pp. 21, 22). It is not my intention to speculate on why Chomsky has in general avoided direct reference to work in UBL. But the fact that such has been his practice greatly complicates my task as an author of a piece titled "Chomsky and Usage-Based Linguistics." What to do then? In the remainder of this chapter, I take particular issues that have been bones of contention between Chomsky and UBLists, attempt to sort out the precise loci of disagreement, and ascertain whether time has brought the opposing sides closer together or farther apart.

18.4 Chomsky and Usage-Based Linguistics: The Long Story

This section takes the most important issues, one-by-one, that separate Chomsky's views from those of UBLists. They are the explananda of linguistic theory (Section 18.4.1), grammar design and architecture (Section 18.4.2), semantics (Section 18.4.3), language acquisition and innately-provided linguistic constructs (Section 18.4.4), functional explanation (Section 18.4.5), and the sources of data on which a linguistic theory might be constructed Section 18.4.6).

18.4.1 The Explananda of Linguistic Theory

In a number of publications, Chomsky has enumerated the three basic questions for linguistics (Chomsky 1986, p. 3; 1988, p. 3; 1991, p. 6):

1. "What constitutes knowledge of language?"
2. "How is knowledge of language acquired?"
3. "How is knowledge of language put to use?"

Observe that the second and third questions demand at least a partial answer to the first, since we can hardly determine how a particular mental faculty is acquired and used without having a pretty good idea of what properties that particular faculty has. Observe furthermore the implicit hypothesis that knowledge of language can be characterized independently from its use.

The explananda of UBL are quite different: "Usage-based theory takes language to be an embodied and social human behavior and seeks explanations in that context. As the

name indicates, this theoretical perspective incorporates the basic insight that usage has an effect on linguistic structure" (Bybee and Beckner 2010, p. 827). In other words, the goal is not to explain how knowledge of language is put to use, but rather the precise opposite – namely, how behavior (including verbal behavior) helps to determine linguistic structure. *Usage* in UBL is understood primarily as acts of communication:

> There may well be instances of verbal behavior which are non-communicative, but this in no way undermines the fundamental functionalist tenet that an understanding of language structure requires an understanding of the functions language can serve, communication being the primary one […]. (Foley and Van Valin 1984, p. 9)

Chomsky could not be more explicit in rejecting the idea that linguistic structure is derived from communication:

> […] language is not properly regarded as a system of communication. It is a system for expressing thought, something quite different. It can of course be used for communication, as can anything people do — manner of walking or style of clothes or hair, for example. But in any useful sense of the term, communication is not the function of language, and may even be of no unique significance for understanding the functions and nature of language. (Chomsky 2002, p. 76)

However, he does not reject tout court that communicative factors might have helped to fine-tune grammatical structure:

> It is possible […] that key computational capacities evolved for reasons other than communication, but after they proved to have utility in communication, were altered because of constraints imposed at both the periphery and more central levels. (Hauser, Chomsky, and Fitch 2002, pp. 1569–1570)

> As [Merge] spread through the population, there would be an advantage to externalization, so the capacity would be linked as a secondary process to the sensorimotor system for externalization and interaction, including communication as a special case. (Berwick and Chomsky 2016, p. 80)

Despite the above, Chomsky has devoted more space to asserting that grammar is poorly designed for communication than that it facilitates communication. By way of example, he has pointed to features such as trace erasure, garden path sentences, and islands as dysfunctional from a communicative point of view (Chomsky 2012, p. 50).

In summary, the explananda of generative grammar and UBL are so completely counterposed that the idea that they might somehow be reconciled is remote.

18.4.2 Grammar Design and Architecture

For Chomsky, the grammatical model has a modular architecture, that is, it is composed of autonomous, though interacting, systems.[4] The number and nature of these systems has changed dramatically over the years, but the basic idea of modularity has remained constant. The number of distinct modules of grammar reached its peak with the Government and Binding (GB) theory, in which syntax alone contained more than a half dozen distinct autonomously functioning modules:

> The full range of properties of some construction may often result from interaction of several components, its apparent complexity reducible to simple principles of separate subsystems. This modular character of grammar will be repeatedly illustrated as we proceed. (Chomsky 1981, p. 7)

In Chomsky's more recent work, the combinatorial (narrow) syntax is no longer conceived of as consisting of interacting modules, each with their own distinct principles, though it partakes in modular interaction with other grammatical components. Indeed:

> […] we propose in this hypothesis that FLN comprises only the core computational mechanisms of recursion as they appear in the narrow syntax and the mappings to the interfaces. (Hauser, Chomsky, and Fitch 2002, p. 1573)

So while there is less modularity in the Minimalist Program than in GB (because there are fewer modules), the basic idea of an overall modular architecture to grammar remains unchanged.

UBL, however, "does not adopt a modular view on language: all structures in language, ranging from morphemes to words to syntactic patterns, are considered as inherently meaningful and, moreover, as being of the same kind, i.e. symbolic form-meaning pairings, called 'symbolic units' (Langacker's Cognitive Grammar) or 'constructions' (Construction Grammar)" (Lemmens 2016, p. 90). By way of example, most UBL theories reject the strict separation of lexicon and syntax and instead refer to *lexicogrammar* or some analogous term (see, for example, Halliday and Matthiessen 2014).

A corollary to the rejection of modularity in UBL is the rejection of the autonomy of syntax:

> Syntax is not autonomous from semantics or pragmatics […] the rejection of autonomy derives from the observation that the use of particular grammatical forms is strongly linked, even deterministically linked, to the presence of particular semantic or pragmatic functions in discourse. (Tomlin 1990, p. 157)

In the view of most UBLists, an autonomous syntax is wrong both empirically and for its putatively rendering impossible any functional explanation for the properties of grammar:[5]

> […] Chomsky (1975) argues for a kind of autonomy of syntax that would cut it off from the pressures of communicative functions. In the Chomskian vision, language is pure and autonomous, unconstrained and unshaped by purpose or function. (Bates and MacWhinney 1989, p. 5)

It is an interesting question whether the autonomy of syntax within generative grammar has become weakened over the years, and thereby bringing generative grammar and UBL to some small extent closer to each other.[6] The following hypotheses, proposed either by Chomsky himself or by his closest co-thinkers, would seem to indicate a "semantic creep" into the syntactic module:

a. the Theta-Criterion (Chomsky 1981), which demands that the syntax know which syntactic elements bear thematic roles and which do not;

b. the idea that c-selection (essentially, subcategorization) is derivable from s-selection (essentially, the thematic properties of the items involved) (Chomsky 1986);
c. the Uniformity of Theta Assignment Hypothesis (UTAH) (Baker 1988), which requires that identical thematic relationships between items are represented by identical structural relationships between those items at the level of D-structure;
d. lexical decomposition, which derives semantically complex predicates via syntactic movement operations (Baker 1988, 1993; Hale and Keyser 1993, 1997; Borer 2003);
e. the cartography program (Rizzi 1997; Cinque 1999), which appeals in part to semantic motivation for syntactic projections;[7] and
f. the triggering of movement (and/or the licensing of configurations) by semantic properties of heads (Rizzi 1991; Haegeman 1995).

It is unclear to me whether Chomsky would acknowledge that the incorporation of the hypotheses a–f represents a weakening of autonomy. He has always taken the position that "In general, as syntactic description becomes deeper, what appear to be semantic questions fall increasingly within its scope […]" (Chomsky 1964a, p. 936). Perhaps he would assert that these hypotheses are no more than illustrations of the result of "deeper syntactic description." And yet, it is hard to imagine thematic roles as anything but inherently semantic. In any event, this weakening of the autonomy of syntax, if that is what it is, hardly represents the removal of an eye-dropper full of water from the gulf that separates Chomsky's views from those of UBL.

18.4.3 Semantics

Chomsky and UBL are united in their rejection of truth-functional approaches to meaning or "formal semantics," as it is informally known (for particularly clear exposition of Chomsky's views, see Chomsky 1979, 1995b). Chomsky argues that many of the expressions that we use in language do not clearly have any correlate in reality, so any theory of language that has a component that requires all expressions to 'hook up with reality' is doomed to failure. Since formal semantics contains such a component, it therefore should be abandoned as fundamentally misguided.

Chomsky's overall view of meaning is, one would have to say, radical. He has speculated that "it is possible that natural language has only syntax and pragmatics" (Chomsky 1995b, p. 26), that is, only "internalist computations and performance systems that access them." Semantic theories are merely "part of an interface level" or "a form of syntax" (Chomsky 1992, p. 223). In this view, there is no distinction between semantics and pragmatics, and *neither* forms a part of linguistic theory, narrowly defined.

While most UBLists would probably agree with Chomsky's reasons for rejecting model-theoretic semantics, in other respects their conception of semantics and its relevance for linguistic theory is diametrically opposed to Chomsky's:

> [UBL] is the most outspoken current attempt to *give meaning a central position in the architecture of the grammar*. In contrast with formal semantics, however, the conception of meaning that lies at the basis of this approach is not restricted to a referential truth-functional type of meaning. Linguistic structures are thought to represent conceptualizations, that is, conceptualization is central for linguistic structure — and conceptualization goes further than mere reference. It involves imagery in the broadest sense of the word: ways of making sense, of imposing meaning. Also, the conceptualizations that are expressed in the language have

> an experiential basis, that is, the link up with the ways in which human beings experience reality, both culturally and physiologically. In this sense, [UBL] embodies a fully contextualized conception of meaning. (Geeraerts and Cuyckens 2007, p. 14; emphasis in original)

In summary, Chomsky's views on the place for semantics in linguistic theory and those of UBLists have little in common.

18.4.4 Language Acquisition and Innately Provided Linguistic Constructs

Chomsky's views on language acquisition and those of UBL are also radically different. UBL takes what it calls a "constructivist" approach to acquisition. In a nutshell, the child *constructs* its grammar based the interaction of experience (its exposure to the ambient speech of the community) and general principles of learning (for the most extensive overview, see Tomasello 2003). Importantly, there are no specifically linguistic universals that guide acquisition. In the UBL view, the not-well-defined notion of "analogy" plays a central role, as the child works from specific utterances to the construction of more general patterns (Tomasello 2003, Lieven, Pine, and Baldwin 1997, Dąbrowska and Lieven 2005). UBLists argue that the stage is set for the emergence of language by around the child's first birthday. At that time, they have learned to establish joint attentional frames with adults, laying an intersubjective ground for communication and within these frames they manage to understand adults' communicative intentions. They also have begun to engage in the role-reversal imitation that forms the basis for conversational interaction. While pure imitation does play a small role in acquisition:

> [children] use their already existing skills of categorization and statistical learning on the utterances they experience to begin moving down the road of grammatical development. In this process children […] extract from utterances and expressions such small things as words, morphemes, and phrases by identifying the communicative job these elements are doing [… and …] they see patterns across utterances, or parts of utterances, with 'similar' structure and function, which enables them to create more or less abstract categories and constructions. (Tomasello 2003, p. 41)

Chomsky, on the other hand, has always rejected the idea that general principles of learning like attention and categorization play a major role in the acquisition of grammatical form:

> […] it seems to me that one must deplore the common tendency to insist that the mechanisms of language must be special cases of 'generalized learning strategies' or general cognitive mechanisms of some sort. […] There seems to be little reason to suppose, for the moment, that there are general principles of cognitive structure, or even of human cognition, expressible at some higher level, from which the particular properties of 'mental organs', such as the language faculty, can be deduced, or even that there are illuminating analogies among these various systems. (Chomsky 1980, pp. 214–215)

If the educated layperson knows anything at all about Chomsky's linguistic ideas, it is that he believes that language acquisition is directed in large part by the innate principles that constitute Universal Grammar (UG). The nature and number of these principles have evolved as the theory has evolved, but the idea of UG-directed acquisition has been present in explicit form since Chomsky (1965) and in implicit form since several years before then.

To be sure, since the late 1970s Chomsky has taken the position that the principles of UG are "parameterized" and that the acquisition process involves the child, based on experience, setting the parameters appropriate to its language. But Chomsky has left no doubt that he believes the set of possible parameter settings to be innate:

> [W]hat we 'know innately' are the principles of the various subsystems of S_0 [= the initial state of the language faculty — FJN] and the manner of their interaction, and the parameters associated with these principles. What we learn are the values of these parameters and the elements of the periphery (along with the lexicon, to which similar considerations apply). The language that we then know is a system of principles with parameters fixed, along with a periphery of marked exceptions. (Chomsky 1986, pp. 150–151)

There has been an interesting rhetorical shift in Chomsky's attitude toward the richness (indeed, the desirability) of a large set of UG principles. At one time, they were viewed in an entirely positive light:

> If the system of universal grammar is sufficiently rich, then limited evidence will suffice for the development of rich and complex systems in the mind […]. Endowed with this system and exposed to limited experience, the mind develops a grammar that consists of a rich and highly articulated system of rules, not grounded in experience in the sense of inductive justification, but only in that experience has fixed the parameters of a complex schematism with a number of options. (Chomsky 1980, p. 66)

Such is no longer the case. Chomsky's current research program is to investigate "how little can be attributed to UG while still accounting for the variety of I-languages attained" (Chomsky 2007, p. 3). Indeed, Chomsky now wishes to shift "the burden of explanation from […] the genetic endowment to […] language independent principles of data processing, structural architecture, and computational efficiency […]" (Chomsky 2005, p. 9). What has driven this change in Chomsky's attitude toward a rich UG? In my view, in 1980 his most important goal was to solve the acquisition problem. In that case, we appeal to a rich UG to "ease the burden" on the child. But now, a central goal of Chomsky's is to solve the evolution problem (see especially Berwick and Chomsky 2016), a problem not on Chomsky's agenda 40 years ago. Clearly, the richer UG is, the more implausible it is that it could have developed by any known processes shaping evolution in general.

Despite the call for a more pared-down UG, Chomsky continues to uphold a Principles and Parameters approach to acquisition. While to my knowledge he himself has not proposed any new parameters for many years, he enthusiastically endorses the work of Charles Yang (Yang 2002), which combines UG-provided parameters with a statistical procedure for identifying the correct settings (see Chomsky 2005, p. 9; 2012, p. 95; Berwick and Chomsky 2016, *passim*).

More than a few of Chomsky's supporters have been troubled by the idea of a plethora of innate parameters in an otherwise Minimalist approach to language (Boeckx 2011; Newmeyer 2004, 2017). A possible alternative is suggested by Pinker and Bloom:

> Parameters of variation, and the learning process that fixes their values for a particular language, as we conceive them, are not individual explicit gadgets in the human mind … Instead, they should fall out of the interaction between the specific mechanisms that define

> the basic underlying organization of language ('Universal Grammar') and the learning mechanisms, some of them predating language, that can be sensitive to surface variation in the entities defined by these language specific mechanisms. (Pinker and Bloom 1994, p. 183)

For an interesting attempt to carry out Pinker and Bloom's program, see Biberauer et al (2014).

18.4.5 Functional Explanation

As discussed in Section 18.2.2, the provision of functional explanations (i.e. explanations external to the grammatical system itself) for the existence and distribution of grammatical forms is central to the UBL research program. It might seem surprising to some, but Chomsky has never opposed the idea of functional explanation. Quite the contrary. In a reply to Searle (1974), Chomsky (1975) wrote that "there are significant connections between structure and function" (p. 56) and to Searle's contention that "it is reasonable to suppose that the needs of communication influenced [language] structure," he responded: "I agree" (p. 58). While he went on to express skepticism that that any comprehensive external explanation of the formal properties of language is likely to be forthcoming and pointed to a fundamental linguistic principle (the structure-dependency of rules) that would appear to have no grounding in communicative function, he was absolutely clear that there is no principled reason that aspects of the language faculty might not have been shaped to meet some external need.

A few years later, Chomsky characterized the suggestion that "functional considerations determine the character of linguistic rules" as a "productive" one (Chomsky 1980, pp. 230–231) and noted that it makes the most sense to speak of functional explanation as applying at the evolutionary level, whether biological evolution or the evolution of a particular language (for similar remarks, see Chomsky 1979, pp. 85–87). For the most part, Chomsky's concrete examples of functional explanation have involved the grammar's responding to perceptual or parsing strategies. Many decades ago, Miller and Chomsky (1963) suggested that there may be a functional explanation for the existence of a transformational component, in that a grammar with transformations is well-adapted to perceptual strategies employing a certain organization of short and longer term memory. In Chomsky and Lasnik (1977, p. 436) a particular filter proposed there was linked to a perceptual strategy and hence "[…] we now have a 'functional explanation' for a rule of grammar […]."

It is certainly true that Chomsky has devoted considerable space to arguing that "[l]anguage design as such appears to be in many respects 'dysfunctional,' yielding properties that are not well adapted to the function language is called upon to perform" (Chomsky 1995a, p. 162). Indeed, the correlation between what is permitted (or prohibited) by the grammar and what is simple (or difficult) from a communicative view has shown to be quite remote (see especially J. D. Fodor 1984). And quite recently, he has written that "it apparently is false" that principles of parsing efficiency may interact with language (Chomsky 2015, p. 29) and that "processing doesn't seem to be a factor" in the origin of optimal design (Chomsky 2015, p. 31). Nevertheless, he stands united with UBL on the idea that external factors can in principle shape grammatical form.

18.4.6 Sources of Data

An overly simplistic view of the differences between Chomskyan linguistics and UBL is that the former relies nearly exclusively on introspective data, typically the intuitions of the researchers themselves, while the former relies on corpora of actual speech. This view contains a kernel of truth. The great majority of published work in generative syntax appeals to introspective data. This is the case for the reasons outlined in Schütze (1996): They provide data not obtainable from spontaneous speech or recorded corpora; they provide negative information, that is, information about what is not possible for the speaker; they allow for the easy removal of irrelevant data, such as slips of the tongue, false starts, etc.; and, more controversially, they allow the researcher to abstract away from the communicative function of language and thereby to focus on the mental grammar as a structural system. Furthermore, it is sometimes claimed that the factors affecting judgments tend to be less mysterious than those affecting use, and that in providing an alternative path to the grammar from language use, "we have a basis on which to search for the common core that underlies both kinds of behavior" (Schütze 1996, p. 180).

The UBL view is quite different:

> Because the linguistic system is so closely tied to usage, it follows that theories of language should be grounded in an observation of data from actual uses of language. […] [T]he primary object of study is the language people actually produce and understand. Language in use is the best evidence we have for determining the nature and specific organization of linguistic systems. Thus, an ideal usage-based analysis is one that emerges from observation of such bodies of usage data, called corpora. … (Barlow and Kemmer 2000, p. xv)

While corpus-based work has always been a the centre of the UBL agenda, it has been claimed that recent advances in technology have facilitated their application:

> Of course, one major impetus for the shift to analysis of natural language use is the recent availability of large electronic corpora and means of accessing particular items and patterns in such corpora. Through the work of corpus linguists, [such as …], access to the nature and range of experience an average speaker has with language is now within our grasp. (Bybee 2006, p. 712)

UBLists object that "the data in generative grammar analyses are almost always disembodied sentences that analysts have made up ad hoc, … rather than utterances produced by real people in real discourse situations … [Only the focus on] naturally occurring discourse [has the potential to lead to] descriptions and explanations of linguistic phenomena that are psychologically plausible" (Tomasello 1998, p. xiii). Along these lines, in a typical UBL anthology (e.g. Bybee and Hopper 2001) the great majority of papers attempt to illustrate that some aspect of grammatical structure can be understood only in terms of the frequency of use of that structure, typically where the relevant data can be obtained only from a large corpus.

Let me illustrate with a few concrete examples. Many UBLists have argued that a causal chain crucially involving corpus-derived frequency facts is central to the understanding of grammatical structure. So Hawkins (1994, 2004) argues that extraposed sentential subjects (e.g. *It is likely that the Raptors will win*) are more frequent in discourse than those in subject position (e.g. *That the Raptors will win is likely*), given that they allow for rapid parsing. Hawkins goes on to suggest that this fact has

a typological reflection: constructions of the latter type are rare cross-linguistically. Haspelmath (2019) argues that all grammatical oppositions involving a minimal meaning difference and a significant frequency difference are reflected in a universal coding asymmetry, i.e. a crosslinguistic pattern in which the less frequent member of the opposition gets special coding. To give a few examples, singular forms virtually always involve less coding than plural or dual forms, nominative forms tend to shorter than oblique forms, and cardinal numerals tend to be more rapidly expressible than ordinals. And virtually all UBLists stress grammaticalization facts as crucial to the construction of an adequate model of grammar. Frequency drives the grammaticalization of locative nouns to adpositions, pronouns to person markers, auxiliaries to tense and aspect particles, and much much more (see Lehmann 1985, Traugott and Heine 1991, Bybee and Hopper 2001). Introspective data would not be much help in arriving at these generalizations.

It is not at all clear to me what Chomsky would say about the factual claims discussed in the preceding paragraph. None of the generalizations discussed there would appear to refute any tenet of generative linguistics. One gets the impression that he finds frequency-triggered facts about linguistic structure to be of little interest for a theory of the cognitive representation of grammar. He has, however, throughout his career, spoken harshly with respect to the use of corpora in linguistic analysis. Some examples follow:

> Any natural corpus will be skewed. Some sentences won't occur because they are obvious, others because they are false, still others because they are impolite. The corpus, if natural, will be so wildly skewed that the description [of language based on the corpus] would be no more than a mere list. (Chomsky 1957, p. 159)

> It seems clear that probabilistic considerations have nothing to do with grammar, e.g. surely it is not a matter for the grammar of English that "New York" is more probable than "Nevada" in the context "I come from –." In general, the importance of probabilistic considerations seems to me to have been highly overrated in recent discussions of linguistic theory. (Chomsky 1964b, p. 215)

> It must be recognized that the notion "probability of a sentence" is an entirely useless one, under any known interpretation of this term. (Chomsky 1969, p. 7)

> Corpus linguistics doesn't mean anything. […] Maybe the sciences should just collect lots and lots of data and try to develop the results from them. Well if someone wants to try that, fine. They're not going to get much support in the chemistry or physics or biology department. But if they feel like trying it, well, it's a free country, try that. We'll judge it by the results that come out. (Chomsky 2004b, p. 97)

The impression that one gets is that for Chomsky "corpus linguistics" involves collecting random masses of data in the hope that something of interest might pop up as a result. However, most UBLists would argue, to the contrary, that corpora are no more than extremely useful tools for testing hypotheses pertaining to the study of grammatical structure, acquisition, and change.

It is interesting that Chomsky, at least in the early years, was fairly critical of introspective data. In *Syntactic Structures* he wrote:

> It is also quite clear that the major goal of grammatical theory is to replace this obscure reliance on intuition by some rigorous and objective approach. (Chomsky 1957, p. 94)

And eight years later in *Aspects of the Theory of Syntax* he wrote:

> Perhaps the day will come when the kinds of data that we now can obtain in abundance [i.e. introspective data — FJN] will be insufficient to resolve deeper questions concerning the structure of language. (Chomsky 1965, p. 21)

Chomsky has never implied that the source of data should be restricted to introspective judgments. For example, he has written: "Suppose there is some data from electrical activity of the brain that bears on, say, word boundaries. Why should that be irrelevant to word boundaries. It just seems absurd to restrict linguistics to the study of introspective judgements, as is very commonly done [especially by some philosophers — FJN]" (Chomsky 1982, p. 33). He does, however, tend to be skeptical that non-introspective sources of data have been a very great utility. To linguists who objected that the database utilized by generativists has been too narrow, he replied:

> [O]ne who believes this might ask what other kinds of evidence would strengthen or undermine the theories we are led to construct on the basis of the (not inconsiderable) evidence that we can now readily obtain. In practice, what has been produced along these lines has not been very informative, but certainly any improvement in this regard will be welcome. (Chomsky 1986, p. 260)

18.5 Conclusion

In this chapter, I have outlined the principal differences between Chomsky's approach to linguistic theorizing and those of usage-based linguists. It seems safe to assert that they are enormous. Whether some ultimate rapprochement is possible is an interesting question, but one that lies beyond the scope of what is written here.

Endnotes

1 I would like to thank Mark Baker, Georges Rey, and an anonymous referee for their comments on a prefinal version of this chapter and Jeff Pelletier, Barbara Partee, and Pieter Seuren for their input on Chomsky's ideas about semantics.
2 Cognitive Linguistics as well as the term *usage-based linguistics* owes its origin to work by Ronald Langacker and George Lakoff in the 1980s (see especially Langacker 1987 and Lakoff 1987).
3 For a very useful overview of different approaches within UBL, see Butler and Gonzálvez-García (2014).
4 Chomsky's use of the terms *module* and *modular* differ from that of Jerry Fodor's, as is discussed in Allott and Smith (Chapter 34 this volume).
5 See Newmeyer (1998, Chapter 2) for an extended argument that the autonomy of syntax and functional explanation are fully compatible.
6 For more discussion of this issue, see Newmeyer (2008).
7 But see Chomsky, Gallego, and Ott (2019) for a critique of the cartography program on minimalist grounds.

References

Baker, M. C. 1988. *Incorporation: A Theory of Grammatical Function Changing*. Chicago: University of Chicago Press.

Baker, M. C. 1993. Noun incorporation and the nature of linguistic representation. In *The Role of Theory in Language Description*, edited by W. A. Foley, 13–44. Berlin: Mouton de Gruyter.

Barlow, M., and S. Kemmer. 2000. Introduction: A usage-based conception of language. In *Usage-Based Models of Language*, edited by M. Barlow and S. Kemmer, vii–xxviii. Stanford: CSLI Publications.

Bates, E., and B. MacWhinney. 1989. Functionalism and the Competition Model. In *The Crosslinguistic Study of Sentence Processing*, edited by B. MacWhinney and E. Bates, 3–73. Cambridge: Cambridge University Press.

Berwick, R. C., and N. Chomsky. 2016. *Why Only Us: Language and Evolution*. Cambridge: MIT Press.

Berwick, R. C., P. Pietroski, B. Yankama, and N. Chomsky. 2011. Poverty of the stimulus revisited. *Cognitive Science*, 35: 1207–1242.

Biberauer, T., A. Holmberg, I. Roberts, and M. Sheehan. 2014. Complexity in comparative syntax: The view from Modern Parametric Theory. In *Measuring Grammatical Complexity*, edited by F. J. Newmeyer and L. B. Preston, 103–127. Oxford: Oxford University Press.

Boas, H. C. 2013. Frame semantics and translation. In *Cognitive Linguistics and Translation: Advances in Some Theoretical Models and Applications*, edited by A. Rojo and J. Ibarretxe-Antuñano, 125–158. Berlin: Mouton de Gruyter.

Boeckx, C. 2011. Approaching parameters from below. In *Biolinguistic Approaches to Language Evolution and Variation*, edited by A. Di Sciullo and C. Boeckx, 205–221. Oxford: Oxford University Press.

Borer, H. 2003. Exo-Skeletal vs. endo-skeletal explanations: Syntactic projections and the lexicon. In *The Nature of Explanation in Linguistic Theory*, edited by J. Moore and M. Polinsky, 31–67. Stanford: CSLI Publications.

Butler, C. S., and F. Gonzálvez-García. 2014. *Exploring Functional-Cognitive Space*. Amsterdam: John Benjamins.

Bybee, J. L. 2006. From usage to grammar: The mind's response to repetition. *Language*, 82: 711–733.

Bybee, J. L. 2010. *Language, Usage, and Cognition*. Cambridge University Press: Cambridge.

Bybee, J. L., and C. Beckner. 2010. Usage-based theory. In *The Oxford Handbook of Linguistic Analysis*, edited by B. Heine and H. Narrog, 827–855. Oxford: Oxford University Press.

Bybee, J. L., and P. Hopper, eds. 2001. *Frequency and the Emergence of Linguistic Structure*. Amsterdam: John Benjamins.

Cedergren, H. J. and D. Sankoff. 1974. Variable rules: Performance as a statistical reflection of competence. *Language*, 50: 333–355.

Chomsky, N. 1957. *Syntactic Structures*. The Hague: Mouton.

Chomsky, N. 1964a. The logical basis of linguistic theory. In *Proceedings of the Ninth International Congress of Linguists*, edited by H. Lunt, 914–977. The Hague: Mouton.

Chomsky, N. 1964b. A transformational approach to syntax. In *The Structure of Language: Readings in the Philosophy of Language*, edited by J. A. Fodor and J. J. Katz, 211–245. Englewood Cliffs, NJ: Prentice-Hall.

Chomsky, N. 1965. *Aspects of the Theory of Syntax*. Cambridge: MIT Press.

Chomsky, N. 1969. Quine's Empirical Assumptions. In *Words and Objections: Essays on the Work of W. V. Quine*, edited by D. Davidson and J. Hintikka, 53–68. Dordrecht: Reidel.

Chomsky, N. 1975. *Reflections on Language*. New York: Pantheon.

Chomsky, N. 1979. *Language and Responsibility: Based on Conversations with Mitsou Ronat*. New York: Pantheon.

Chomsky, N. 1980. *Rules and Representations*. New York: Columbia University Press.

Chomsky, N. 1981. *Lectures on Government and Binding*. Dordrecht: Foris.

Chomsky, N. 1982. *The Generative Enterprise: A Discussion with Riny Huybregts and Henk van Riemsdijk*. Dordrecht: Foris.

Chomsky, N. 1986. *Knowledge of Language: Its Nature, Origin, and Use*. New York: Praeger.

Chomsky, N. 1988. *Language and Problems of Knowledge: The Managua Lectures*. Cambridge: MIT Press.

Chomsky, N. 1991. Linguistics and adjacent fields: A personal view. In *The Chomskyan Turn: Generative Linguistics, Philosophy, Mathematics, and Psychology*, edited by A. Kasher, 3–25. Oxford: Blackwell.

Chomsky, N. 1992. Explaining language use. *Philosophical Topics*, 20: 205–231.

Chomsky, N. 1995a. *The Minimalist Program*. Cambridge: MIT Press.

Chomsky, N. 1995b. Language and nature. *Mind*, 104: 1–61.

Chomsky, N. 2002. *On Nature and Language*. Cambridge: Cambridge University Press.

Chomsky, N. 2004a. *The Generative Enterprise Revisited: Discussions with Riny Huybregts, Henk van Riemsdijk, Naoki Fukui and Mihoko Zushi*. Berlin: Mouton de Gruyter.

Chomsky, N. 2004b. The master and his performance: An interview [by József Andor] with Noam Chomsky. *Interactional Pragmatics*, 1: 93–111.

Chomsky, N. 2005. Three factors in language design. *Linguistic Inquiry*, 36: 1–22.

Chomsky, N. 2007. Approaching UG from below. In *Interfaces + Recursion = Language?* edited by U. Sauerland and H. Gärtner, 1–29. Berlin: Mouton de Gruyter.

Chomsky, N. 2009. Conclusion. In *Of Minds and Language: A Dialogue with Noam Chomsky in the Basque Country*, edited by M. Piatelli-Palmarani, J. Uriagereka, and P. Salaburu, 379–409. Oxford: Oxford University Press.

Chomsky, N. 2012. *The Science of Language: Interviews with James McGilvray*. Cambridge: Cambridge University Press.

Chomsky, N. 2015. *The Sophia Lectures [= Sophia Linguistica, No. 64]*. Tokyo: Sophia Linguistic Institute for International Communication.

Chomsky, N. 2016. *What Kind of Creatures Are We?* New York: Columbia University Press.

Chomsky, N., and H. Lasnik. 1977. Filters and control. *Linguistic Inquiry*, 8: 425–504.

Chomsky, N., Á. J. Gallego, and D. Ott. 2019. Generative Grammar and the Faculty of Language: Insights, Questions, and Challenges. *Catalan Journal of Linguistics, Special Issue*, 229–261.

Cinque, G. 1999. *Adverbs and Functional Heads: A Cross-Linguistic Perspective*. Oxford: Oxford University Press.

Clark, A. and R. Eyraud. 2007. Polynomial time identification in the limit of substitutable context-free languages. *Journal of Machine Language Research*, 8: 1725–1745.

Croft, W. 2001. *Radical Construction Grammar: Syntactic Theory in Typological Perspective*. New York: Oxford University Press.

Dąbrowska, E., and E. Lieven. 2005. Towards a Lexically Specific Grammar of Children's Question Constructions. *Cognitive Linguistics*, 16: 437–474.

Davis, J., R. J. Gorup, and N. Stern, eds. 2006. *Advances in Functional Linguistics: Columbia School Beyond Its Origins*. Amsterdam: John Benjamins.

Dedieu, D., and S. C. Levinson. 2013. On the antiquity of language: The reinterpretation of Neandertal linguistic capacities and its consequences. *Frontiers in Psychology*, 4: 1–17.

Du Bois. J. 1985. Competing motivations. In *Iconicity in Syntax*, edited by J. Haiman, 343–365. Amsterdam: John Benjamins.

Elman, J. L. 1991. Distributed representations, simple recurrent networks, and grammatical structure. *Machine Learning*, 7: 195–225.

Feldman, J. A., E. K. Dodge, and J. E. Bryant. 2010. Embodied construction grammar. In *The Oxford Handbook of Linguistic Analysis*, edited by B. Heine and H. Narrog, 111–138. Oxford: Oxford University Press.

Foley, W. A., and R. D. Van Valin. 1984. *Functional Syntax and Universal Grammar*. Cambridge: Cambridge University Press.

Geeraerts, D., and H. Cuyckens, eds. 2007. *The Oxford Handbook of Cognitive Linguistics*. Oxford: Oxford University Press.

Goldberg, A. E. 2006. *Constructions at Work: The Nature of Generalization in Language*. Oxford: Oxford University Press.

Haegeman, L. 1995. *The Syntax of Negation*. Cambridge: Cambridge University Press.

Hale, K., and S. J. Keyser. 1993. On Argument Structure and the Lexical Expression of Syntactic Relations. In *The View from Building 20: Essays in Honor of Sylvain Bromberger*, edited by K. Hale and S. J. Keyser, 53–110. Cambridge, MA: MIT Press.

Hale, K., and S. J. Keyser. 1997. On the complex nature of simple predicates. In *Complex Predicates*, edited by A. Alsina, J. Bresnan, and P. Sells, 29–65. Stanford: CSLI Publications.

Halliday, M. A. K, and C. Matthiessen. 2014. *An Introduction to Functional Grammar, 4th Edn*. London: Rutledge.

Haspelmath, M. 2019. Explaining grammatical coding asymmetries: Form-frequency correspondences and predictability. Ms, University of Leipzig.

Hauser, M. D., N. Chomsky, and W. T. Fitch. 2002. The faculty of language: What is it, who has it, and how did it evolve? *Science*, 298: 1569–1579.

Hawkins, J. A. 1994. *A Performance Theory of Order and Constituency*. Cambridge: Cambridge University Press.

Hawkins, J. A. 2004. *Efficiency and Complexity in Grammars*. Oxford: Oxford University Press.

Hengeveld, K.. and J. L. Mackenzie. 2008. *Functional Discourse Grammar: A Typologically Based Theory of Language Structure*. Oxford: Oxford University Press.

Hudson, R. A. 2007. *Language Networks: The New Word Grammar*. Oxford: Oxford University Press.

Kuno, S. 1980. Functional syntax. In *Syntax and Semantics, Volume 13*, edited by E. Moravcsik and J. R. Wirth, 117–136. New York: Academic Press.

Kuno, S. 1987. *Functional Syntax: Anaphora, Discourse, and Empathy*. Chicago: University of Chicago Press.

Lakoff, G. 1987. *Women, Fire, and Dangerous Things: What Categories Reveal about the Mind*. Chicago: University of Chicago Press.

Langacker, R. W. 1987. *Foundations of Cognitive Grammar: Volume 1; Theoretical Prerequisites*. Stanford: Stanford University Press.

Lehmann, C. 1985. Grammaticalization: Synchronic variation and diachronic change. *Lingua e Stile*, 20: 303–318.

Lemmens, M. 2016. Cognitive semantics. In *The Routledge Handbook of Semantics*, edited by N. Riemer, 90–105. London: Routledge.

Lieven, E., J. M. Pine, and G. Baldwin. 1997. Lexically-based learning and early grammatical development. *Journal of Child Language*, 24: 187–219.

Martinet, A. 1962. *A Functional View of Language*. Oxford: Oxford University Press.

Miller, G., and N. Chomsky. 1963. Finitary models of language users. In *Handbook of Mathematical Psychology, Volume 2*, edited by P. Luce, R. Bush, and E. Galanter, 419–492. New York: Wiley.

Newmeyer, F. J. 1998. *Language Form and Language Function*. Cambridge: MIT Press.

Newmeyer, F. J. 2004. Against a parameter-setting approach to language variation. *Linguistic Variation Yearbook*, 4: 181–234.

Newmeyer, F. J. 2008. Semantic evidence and syntactic theory. In *The Fruits of Empirical Linguistics, Volume 1: Process*, edited by S. Featherstone and S. Winkler, 177–210. Berlin: Mouton de Gruyter.

Newmeyer, F. J. 2017. Where, if anywhere, are parameters?: A critical historical overview of parametric theory. In *On Looking into Words (and Beyond): Structures, Relations, Analyses*, edited by C. Bowern, L. Horn, and R. Zanuttini, 545–566. Berlin: Language Sciences Press.

Prince, E. F. 1988. Discourse analysis: A part of the study of linguistic competence. In *Linguistics: The Cambridge Survey, Volume 2: Linguistic Theory: Extensions and Implications*, edited by F. Newmeyer, 164–182. Cambridge: Cambridge University Press.

Reali, F., and M. Christiansen. 2005. Uncovering the richness of the stimulus: Structure dependence and indirect statistical evidence. *Cognitive Science*, 29: 1007–1028.

Rizzi, L. 1991/1996. Residual verb second and the *wh*-criterion. In *Parameters and Functional Heads: Essays in Comparative Syntax*, edited by A. Belletti and L. Rizzi, 63–90. Oxford: Oxford University Press.

Rizzi, L. 1997. The fine structure of the left periphery. In *Elements of Grammar: Handbook of Generative Syntax*, edited by L. Haegeman, 281–337. Dordrecht: Kluwer.

Ruiz de Mendoza Ibáñez, F. J., and A. Galera Masegosa. 2014. *Cognitive Models and Cognitive Operations: Levels of Representation and Explanatory Adequacy*. John Benjamins: Amsterdam.

Schütze. C. 1996. *The Empirical Basis of Linguistics: Grammaticality Judgments and Linguistic Methodology*. Chicago: University of Chicago Press.

Searle, J. R. 1974. Chomsky's Revolution in linguistics. In *On Noam Chomsky: Critical Essays*, edited by G. Harman, 2–33. Garden City, NY: Anchor Books.

Stefanowitsch, A. 2013. Collostructional analysis. In *The Oxford Handbook of Construction Grammar*, edited by T. Hoffmann and G. Trousdale, 290–306. Oxford: Oxford University Press.

Taylor, J. R. 2010. *Cognitive Grammar*, Oxford University Press: Oxford.

Tomasello, M. 2003. *Constructing a Language: A Usage-Based Theory of Language Acquisition*. Cambridge, MA: Harvard University Press.

Tomasello, M., ed. 1998. *The New Psychology of Language: Cognitive and Functional Approaches to Language Structure*. Mahwah, NJ: Lawrence Erlbaum.

Tomasello, M. 2009. UG Is Dead. *Behavioral and Brain Sciences*, 32: 470–471.

Tomlin, R. S. 1990. Functionalism in Second Language Acquisition. *Studies in Second Language Acquisition*, 12: 155–177.

Traugott, E. C., and Bernd Heine, eds. 1991. *Approaches to Grammaticalization, Volume 1: Focus on Theoretical and Methodological Issues*. Amsterdam: John Benjamins.

Van Valin, R. D., and R. J. LaPolla. 1997. *Syntax: Structure, Meaning, and Function*. Cambridge: Cambridge University Press.

Yang, C. D. 2002. *Knowledge and Learning in Natural Language*. Oxford: Oxford University Press.

Part IV

Processing and Acquisition

19

Sentence Processing and Syntactic Theory

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19.1 Introduction

The study of comprehending language in real-time is a central component of the modern linguistic enterprise. In this chapter, we explore some ways in which Chomsky's linguistic work has influenced research on one domain of linguistic performance, sentence processing, over the last half century.

Modern research on sentence processing is a cognitivist discipline: Broadly speaking, most researchers assume that understanding sentences requires constructing (a series of) mental representations. Theories attempt to understand the underlying mental computations or principles that are involved in the incremental construction of said representations in real time. Insofar as sentence processing presupposes the cognitivist framework, Chomsky's general influence is indisputable: Chomsky was an integral member of the group of researchers that brought about the shift toward cognitivism across the psychological sciences (e.g. Anderson 1976; Fromkin 1971; Garrett 1975; Miller 2003), and he vigorously argued that language could, and should, be studied as a cognitive science.

Chomsky's influence on sentence processing research goes much deeper. In the 1950s, Chomsky offered a new vision for linguistic research and syntacticians in particular. The job of syntacticians was to formulate grammars that characterize a native speaker's knowledge of which syntactic representations are well-formed in her native language and which are not. These grammars were supposed to offer both broad and deep explanatory coverage across a wide range of linguistic phenomena using maximally general principles. In response to this charge, work on formal grammars exploded, resulting in a variety of highly articulated formal theories and accounts of linguistic phenomena that had hitherto been neglected or unknown.

Chomsky famously maintained the importance of distinguishing linguistic *competence* from linguistic *performance* (e.g. Chomsky 1965). The grammars that syntacticians formulated were supposed to abstract away from "memory limitations, distractions,

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shifts of attention and interest, and errors (random or characteristic) … " that affect how one understands actual sentences in real time (Chomsky 1965, p. 3). The fact that competence grammars abstract away from performance considerations might lead to the misconception that grammatical theory is irrelevant to sentence processing research, or that sentence processing research is, in turn, irrelevant to grammatical theorizing.

In this chapter, we hope to disabuse readers of this misconception. We provide some examples of how grammatical theory has been – and continues to be – integral to the study of linguistic performance. We seek to show, that Chomsky's claim in *Aspects of the Theory of Syntax* is largely borne out: "the study of performance will proceed only as far as the study of the underlying competence permits" (Chomsky 1965, p. 8). The moral is that we have won insights into the nature of the parser, its operating principles, and aspects of the larger cognitive architecture in which it is embedded specifically by using grammatical representations as the basis for psycholinguistic theorizing: Grammars specify the representations and relations that should (ideally) be computed by the parser. Only when we have a theory of *what* the parser computes, can we generate and evaluate substantive hypotheses about (*whether* and) *how* it is actually computed.

Before proceeding further, we must briefly address a question about the scope of modern sentence processing research and its relationship to specific grammatical formalisms. It is not uncommon for researchers (especially formal linguists and philosophers) to assume that a central goal of psycholinguistic research is to validate or falsify particular grammatical analyses.[1] Although psycholinguistic results may, in principle, bear on questions of grammatical formalism, most workaday sentence processing researchers do not see themselves as arbiters of formal linguistic disputes. This is partly for practical reasons: Arguments for or against grammatical formalisms generally turn on very fine-grained representational differences. Unfortunately, our current hypotheses about how to link grammatical representations and operations to parsing algorithms do not allow us to test differences at the desired level of resolution (see, e.g. Phillips and Wagers, 2007; Kush and Dillon, *to appear* for further discussion). Individual grammars are compatible with a wide variety of conceivable processing models.[2] It is an empirical question as to which is the right one.

Thus, instead of deciding between one grammatical formalism over another, the day-to-day job of most sentence processing researchers is to pin-down and characterize incremental processing operations at a level that abstracts over very fine-grained grammatical details. The enterprise is thus relatively *formalism*-neutral, but, as we will show below, it is not *theory*-neutral. Grammatical analysis is presupposed. Researchers learn about implementation by investigating phenomena where *all* grammatical formalisms make representational commitments.

In what follows, we provide worked-through illustrations of how psycholinguists investigate the algorithmic computation of linguistic representations. It's interesting to note that the three examples we chose to illustrate this are model cases that were foundational in the development of both grammatical theory and psycholinguistic theory alike. We begin by reviewing the literature on incremental ambiguity resolution, move to the processing of long-distance *filler-gap* dependency processing, and conclude with the processing of anaphoric relations. At each point along the way, we will underscore the centrality of grammatical representations in the models considered.

19.2 Ambiguity Resolution and Reanalysis

We begin with an illustration using perhaps the most-studied phenomenon in sentence processing: ambiguity resolution in garden-path sentences. Native speakers of English tend to reject the string in (1) as an ill-formed sentence upon first encountering it. Their intuition is that the verb *stumbled* cannot be integrated with the preceding words.

(1) The dog raced around the track stumbled.

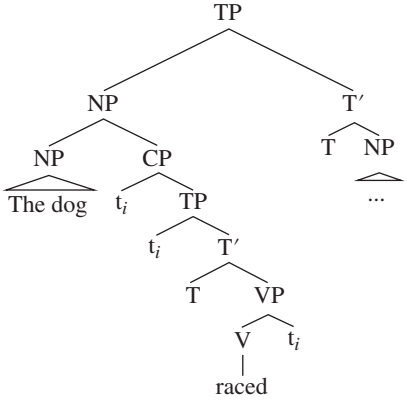
The unacceptability of the sentence is surprising from a purely grammatical perspective. There is a well-formed grammatical analysis for the string under which the substring *the dog raced around the track* should be analyzed as an NP containing a reduced relative clause (henceforth *RedRC*), which is then the subject of *stumbled*. The realization that (1) is, in fact, grammatical can be primed by example. (1) can be analyzed as structurally equivalent to the less difficult (2) and interpreted as synonymous with (3).

(1) [The dog thrown the ball] stumbled.
(3) The dog [that was raced around the track] stumbled.

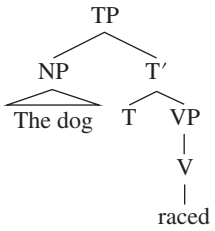
Since the perception of unacceptability is not likely grammatical in origin, we can assume that it arises because parsers fail to analyze the sentence correctly (though cf. McKoon and Ratcliff, 2003). The standard explanation of the effect is as follows. During left-to-right processing, the parser encounters a point of *local syntactic ambiguity* at the verb *raced*. The incomplete input is compatible with two divergent syntactic analyses: the RedRC analysis (4a) or a simple main verb analysis (4b). Under (4a) *the dog* is the object of the (passivized) transitive verb *raced*. Under (4b) *the dog* is the subject of the intransitive main verb *raced*. The parser erroneously prefers to pursue the analysis in (4b) and continues down the "garden path" until it reaches *stumbled,* which cannot be grammatically integrated into the representation under construction.

(4) The dog *raced* …

(4a)



(4b)



Garden-path sentences have been used to study (i) the real-time *generation* of grammatical structures, (ii) the implicit *decision processes* that guide selection of an analysis under conditions of uncertainty, and (iii) how closely the incremental representations we generate align with those specified by the grammar. In order to illustrate how the phenomenon has contributed to psycholinguistic theorizing, we start by outlining a well-known model and then consider how other models diverge.

Frazier and Rayner (1982) proposed the *garden-path* (GP) processing model in which incoming words are incrementally integrated into the developing sentence representation in accordance with grammatical rules. Parsing occurs *serially*: only a single representation can be elaborated at any time. When confronted with local syntactic ambiguity, the parser is forced to commit to one of the analyses. An initial candidate is selected via constituency-based principles. Here the relevant principle was *Minimal Attachment* (see Frazier 1979), which reflects a preference for less complex analyses over more complex ones. Minimal attachment (MA) was proposed not as a heuristic principle in its own right, but as a side-effect of a sentence processing mechanism that attempted to find the first available analysis and take it: Frazier hypothesized that analyses that had more elaborate syntactic structure took more time to compute, and therefore, were unlikely to be selected as the initial parse.

Minimal attachment: Attach incoming material to the phrase marker being constructed using the fewest nodes consistent with the well-formedness rules of the language under analysis.

According to MA, the parser should prefer (4b) over (4a) because (4b) has fewer nodes.[3]

The GP model made substantive mentalistic commitments about how ambiguity is handled and the nature of the parser more generally. Initial attachment decisions were based on *syntactic complexity,* initial syntactic decisions were *informationally encapsulated* (in the sense of Fodor 1983), the parser operated serially, and the incremental representations computed by the parser were strictly subject to grammatical well-formedness conditions.

Subsequent models have challenged either one or some combination of these commitments. One strand of recent work in the *Surprisal* framework (Hale 2001; Levy 2008) rejects this approach, choosing to model sentence processors as *rational* agents that make decisions to optimize the probability of success or effectiveness in their environments (Shepard, 1987; Anderson, 1990; Tenenbaum and Griffiths, 2001).[4] Attachment decisions could be governed by semantic/discourse simplicity biases (e.g. Crain and Steedman 1985),[5] or by the frequency of the candidate parses (e.g. Hale 2001; Levy 2008). According to frequency-based accounts structures that are encountered more often in every-day language experience are deemed to be more likely

to be used in later experience. A number of researchers rejected encapsulation, arguing for models of ambiguity resolution in which attachment decisions simultaneously and probabilistically took multiple information sources into account (e.g. Spivey and Tanenhaus 1998; McRae et al. 1998; Tanenhaus et al., 1995; see also Altmann and Kamide, 1999; Trueswell et al., 1994; MacDonald, 1993). Other models assume that the parser can simultaneously entertain and elaborate multiple analyses *in parallel* (Boston Ferrara, Hale and Vasishth, 2011; Gibson, 1991; Hale, 2001; Stevenson and Merlo, 1997; Tabor and Hutchins, 2004; *i.a.*), perhaps with variable limits on the degree of parallelism (Hale 2014). Preference effects are accounted for by assuming that different parses are *ranked*.

Some accounts of garden-path effects reject the idea (to a greater or lesser degree) that the representations computed by the incremental parser conform to the strictures of the grammar. Bever and Townsend (2001) argued that the initial representations generated by the parser are only indirectly related to grammatical analyses. This approach holds that people first understand sentences by applying heuristic perceptual templates to the input. Difficulty in parsing (1) arises because participants automatically apply a linear template [NP V PP] to the input that maps the first NP to a subject role of the V.

More recent research allows for temporary or small deviations from grammatical well-formedness. Tabor and colleagues have proposed a model in which the structure-generating portion of the parser can temporarily consider analyses that are not wholly consistent with the grammar. Tabor, Galantucci, and Richardson (2004) compared how participants processed sentences like those in (5):

(5) a. The coach smiled at the player ***tossed/thrown*** a frisbee by …
b. The coach smiled at the player who was ***tossed/thrown*** a frisbee by …

The authors asked whether participants encountered more incremental difficulty parsing the RedRC *the player tossed/thrown the frisbee* … when the verb was *thrown* than *tossed*. *Thrown* is unambiguously a past participle, definitively signaling a RedRC parse. Grammatically, *tossed* must be a past participle heading a RedRC, but *tossed* is form identical to its main verb counterpart. Tabor and colleagues were interested in whether the form of the verb would cause readers to consider the main clause analysis (i.e. treat *the player* as the subject of *tossed a frisbee*) even though the parse was *not locally ambiguous*, per se. The authors found that readers had more difficulty with the RedRC headed by *tossed* than *thrown*. They reasoned that increased difficulty arose because the incorrect parse interfered with the construction of the grammatically acceptable parse. Tabor and colleagues propose that effects can be explained by *self-organizing parsing* (SOP) models (Tabor et al. 2004; Tabor and Hutchins 2004) in which words are stored in memory as (grammatically well-formed) tree-fragments that have requirements (e.g. argument structure) that must be met via connection to other treelets. When a word is read, its treelet is activated and begins to establish links with other treelets to satisfy its syntactic or thematic requirements. Treelets can, in principle, establish concurrent bonds with multiple items and the various bonds are weighted according to how compatible they are with the input. The model therefore allows the parser to consider εlocally coherent" parses of subsets of the input strings incompatible with the global grammatical analysis. A related theory of sentence processing holds that cue-based memory retrieval is a key component of establishing linguistic dependencies during the

course of incremental sentence processing (Lewis and Vasishth 2005; Lewis, Vasishth, and Van Dyke 2006; Van Dyke 2007; Van Dyke and Lewis, 2003). Cue-based memory retrieval involves matching a set of retrieval cues against the contents of working memory to bring previously processed representations back into the focus of attention. This cue-matching process can sometimes lead the parser to retrieve and build dependencies with grammatically inaccessible constituents (Van Dyke 2007). Thus, like SOP, these models also allow for limited departures from the grammatical ideal as a direct result of the structure-building processes engaged by the parser. Though we do not endorse the model personally, we acknowledge that it represents a substantive hypothesis about the nature of the parser's structure-generating subroutines.[6]

Another finding from the garden-path parsing literature has contributed to the debate on representational fidelity. When reading sentences like (6), participants exhibit difficulty at the verb *spit up*.

(6) While Anna dressed the baby spit up on the bed.

The intuitive explanation is that participants first treat *the baby* as the object of *dressed*. Then, when they arrive at *spit up,* it appears as though there is no subject for the main verb. The appropriate parse of the sentence is to treat *dressed* as a reflexive verb and the baby as the main subject. Thus, participants must *revise* their initial parse from (7a) to (7b):

(7) a. [while Anna dressed the baby], …
b. [while Anna dressed], *the baby* …

In a series of experiments Fernanda Ferreira and colleagues have shown that after reading sentences like (6) interpretations associated with the inaccurate parse persist: If asked whether Anna dressed the baby, participants respond "yes" on a non-negligible number of trials (Christianson et al. 2001, 2006; Ferreira 2003; Ferreira et al. 2001; Swets et al. 2008). The errors were interpreted as evidence that parsers can end up with "good enough" structural representation where *the baby* is both the object of the verb *dressed* and the subject of *spit up*, in violation of the grammar. This intuition was developed into a larger theory of *Good Enough processing* in which parsers heuristically build a "rough-and-ready" parse of the sentence that can deviate from the grammar's representations (see Sanford and Sturt 2002 for a broader overview of underspecification and shallow processing). An alternate explanation of the effects is possible, under which the parser only builds relations sanctioned by the grammar. Under this second interpretation, structural reanalysis may fail to reliably trigger revision of incremental semantic commitments triggered by earlier parses (e.g. Slattery et al. 2013).

Having sketched models of incremental sentence processing, we should pause to consider what role grammatical representations play in the models above. All but one of the models presuppose that parsers experience difficulty in (1) because they must choose between two *syntactic* representations that more or less conform to the conditions imposed by the competence grammar. Though some models allow for the representations generated by the parser to depart from a strict grammatical template, these departures are constrained. In point of fact, the underlying intuitions of these models can only be articulated in response to the default assumption that representations considered by the parser are those of the grammar.

19.3 Filler-Gap Dependency Processing

In most syntactic theories, argument roles are determined via *local* syntactic relations: *The jerky* is interpreted as a direct object of *chew* in (8) because it is sister to the verb in the syntactic tree.

(8) Loki chewed the jerky.

Even though a reliable position-to-interpretation mapping is possible in simple sentences, natural language is rife with constructions where a strict mapping appears not to work. In the *wh*-question (9a), the sentence-initial phrase *which jerky* is interpreted as the direct object of *chew* as though it occupied the verb's object position (denoted by the *gap* "__"). This is similar for the head of the relative clause *jerky* in (9b).

(9) a. Which jerky did Loki chew __?
b. The jerky that Loki chewed __ was tough.

Grammatical theories hold that the phrase *which jerky* establishes a dependency with the gap (at some level of representation).[7] Adopting standard psycholinguistic terminology, we refer to the displaced phrase as the *filler* and the dependencies as *filler-gap dependencies* (FGDs). Within Generative Grammar (starting with Chomsky 1957 and continuing up through Chomsky 1995), the standard analysis maintains a uniform position-to-interpretation mapping by positing that *which jerky* is the sister to the verb *chew* at some level of syntactic representation. The two positions are linked via a transformational operation (*movement*).

Grammatical theories of filler-gap constructions hold that a dependency must be established between a filler and its gap site. Thus, if parsers compute grammatical representations, we expect that the gap site should correspond to a locus of incremental computation: Once the parser recognizes a gap site, processes associated with role assignment can ensue and representations be elaborated. There is substantial evidence that increased computation coincides with gap position during the incremental processing of FGDs (e.g. see the electrophysiological evidence from Kaan et al. 2000; Fiebach et al. 2002; Phillips et al. 2005; Gouvea et al. 2010).

Processing filler-gap dependencies requires managing incremental uncertainty about where a gap will fall in the upcoming sentence. To illustrate: there are multiple (potentially infinite) possible grammatical continuations for the fragment in (10).

(10) **Which jerky** did Loki …
a. … *chew* __ behind the couch?
b. … think __ was behind the couch?
c. … find a place to hide __ ?
d. … think Tor convinced Jorge that he should *buy* __?

As with ambiguity resolution, a line of research that deals with exactly how the parser deals with incremental indeterminacy in filler-gap processing has yielded insights into the nature of the parser. Broadly speaking, there are two strategies that a parser might adopt after encountering a filler. It could either passively wait for unambiguous evidence of the true gap position in the sentence, or it could *actively* posit a gap whenever

the incomplete string was compatible with a grammatical analysis (Fodor 1978; Frazier 1987). Research provides overwhelming evidence for active gap-filling (AGF). So-called *filled-gap effects* are one type. An example: Stowe (1986) compared incremental reading times between minimally different sentences like (11a) and (11b). In particular, Stowe was interested in whether participants would respond differently to the word *us* in the two sentences.

(11) My brother wanted to know …
  a. **who** Ruth will bring **us** home to at Christmas.
  b. **whether** Ruth will bring **us** home to Mom at Christmas.

Stowe found that readers spent more time reading *us* in (11a) than in (11b). The slowdown is predicted by AGF: if participants preemptively committed to a representation that treated *who* as the direct object of *bring* as soon as the verb was encountered, then they should experience difficulty when they read the true direct object *us,* which disconfirms this analysis. The gap-driven model predicts that there should be no such difference because the parser should not eagerly commit to treating *who* as the object of *bring* (see also Crain and Fodor 1985).

One of the most puzzling facts uncovered by research in Generative syntax is the existence of syntactic domains that block filler-gap association, so-called *islands* (Ross 1967; Chomsky 1977). Relative clauses (RCs) are examples of islands: The filler *which jerky* can easily be associated with an object gap after *was chewing* in simple complement clauses (12a), but the same dependency results in unacceptability if *ate* is embedded inside a RC (12b).

(12) a. *Which book* did Tor say that the happy dog was chewing ___?
  b. **Which book* did Tor say that the dog [that was chewing ___] was happy?

Researchers have used islands to further probe the mechanisms underlying incremental filler-gap processing (e.g. Stowe 1986; Traxler and Pickering 1996; Phillips 2006; Yoshida et al. 2004). For example, some studies test whether the parser "blindly" searches for the first verb in the linear string when attempting to discharge a filler, or whether it is "smarter," choosing only to posit gaps where they would result in acceptable dependencies. In an eye-tracking study, Traxler and Pickering (1996) found that signs of AGF were apparent at the verb *wrote* in (13a), but not in (13b), where the verb was embedded inside an island.

(13) a. The book that the author wrote regularly about ___ was nice.
  b. The book that the author [RC who wrote regularly] reviewed was nice.

Thus, it appears that AGF is suspended inside islands. The parser does not operate in such a way that would lead it to temporarily consider FGDs that are judged to be unacceptable offline. The exact reason for why gaps inside islands are unacceptable is still a matter of debate. Some researchers hold that syntactic constraints prohibit FGDs into islands (e.g. Chomsky 1977). As such, the parser could be said to operate in lockstep with the grammar (Phillips 2006). Other frameworks reject a syntactic explanation, opting instead for semantic/pragmatic constraints (Erteschik-Shir 1981; Kuno 1987; Deane 1992, a.o.), frequency effects (Chaves 2013; Hofmeister et al.

2013), or processing/memory explanations (e.g. Kluender and Kutas 1993). We think the evidence against simple memory-limitation accounts is strong (see Sprouse, Wagers and Phillips 2012a,2012b). Irrespective of the ultimate correct explanation, psycholinguistic investigation of islands, a phenomenon uncovered by formal grammatical research, has resulted in greater knowledge of the nature of the parser.

Because they require the pairing of distant elements, FGDs make demands on memory. Consequently, examining the processing of FGDs has provided insight into the nature of the memory architecture and systems that subserve sentence processing. We briefly consider one case.

Chomsky and Miller (1963, p. 467) famously discussed cases where memory limitations appear to negatively affect the parser's ability to compute grammatical FGDs. They noted that it was "possible that [the parser] will not contain enough computing space to allow it to understand all sentences in the manner of the [grammar] whose instructions it stores." The example most often given to support this observation is doubly center-embedded relative clauses. The sentence in (14) is typically perceived as ill-formed:

(14) The dog that the student that the vet knows loves is kind of a spitfire.

Chomsky and Miller (1963) argued that the perceived unacceptability of (14) should be attributed to shortcomings of the parser, and not the grammar, because an independently motivated simple grammar with recursive rule application could generate a structure for the string in (14). Intuitively, parsing (14) is difficult because it requires simultaneously keeping track of multiple unintegrated fillers before a gap site is encountered. Interestingly, (15) is structurally identical to (14) in all relevant respects, but it is easier to parse (e.g. Gibson and Warren 2002).

(15) The dog that everyone we know loves is kind of a spitfire.

The acceptability of (15) demonstrates two things. First, insofar as the syntactic structures of (14) and (15) are identical, then (14) is grammatically well-formed. Second, the unacceptability of (14) cannot be linked to the quantity of unintegrated fillers alone. The features of the intervening NPs must be taken into account.

Less well-known is that the properties of the parser can, in fact, lead to spurious amelioration of sentences, leading to so-called εgrammatical illusions" in which a sentence sounds acceptable, despite not receiving a licit grammatical analysis (Phillips, Wagers and Lau 2011). Sticking with the center embedding examples, consider (16):

(16) The dog that the student that Jorge knows is kind of a spitfire.

Astonishingly, (16) often sounds *better* to native English speakers than does (14), despite the fact that it is missing one of the grammatically required verbs and is therefore ungrammatical (Frazier 1985; Gibson 1998). This missing V2 effect is similarly attributed to memory limitations in the parser, but of a more subtle fashion than the center-embedding crash observed in (16). It seems that comprehenders lose track of the number of open subject–verb dependencies when they stack up in memory, and that when they lose track of one of those dependencies, their ability to confirm that it has been grammatically completed is diminished. Parser-grammar disconnects

such as those seen in double center-embedding sentences have been influential for psycholinguists attempting to understand the information processing principles that govern language use (see Phillips, Wagers and Lau 2011 for a broader discussion of other illusions of grammaticality).

As this brief survey suggests, the study of filler-gap processing has been influential in a range of different areas for psycholinguists. It has informed questions of incremental syntactic analysis, the management of long-distance relationships in working memory during sentence processing, and has yielded insights into apparent disconnects between the parser and the grammar. In this way, grammatical movement operations have been an important model system for both psycholinguists and linguists.

19.4 Anaphoric Relations

Another area where Chomsky's research has had an impact on psycholinguistic research is the processing of anaphoric relations. Anaphoric items like reflexives (*himself* in 17a) and pronouns (*him* in 17b) must be linked to antecedents to be fully interpreted. In (17), the reflexive and the pronoun can be co-interpreted with the gender-matching NPs *Tor/Loki* in their respective sentences.

(17) a. *Tor/Loki* licked $himself_i$.
b. *Tor/Loki* thought someone would lick him_i.

Interestingly, co-interpretation is not always possible. Native speakers have the intuition that *Loki* cannot co-refer with *himself* in (18a) or with *him* in (18b). The sentences in (18) are unacceptable on that interpretation, indicated via co-indexation.

(18) a. $^*Loki_k$ thought that someone would lick $himself_k$.
b. *Someone thought that $Loki_k$ would lick him_k.

Since the 1970s (Reinhart 1976; Lasnik 1976), work in the Generative tradition has tried to explain these facts and worked to formalize constraints that govern the distribution of acceptable antecedents. Chomsky's (1986) Binding theory proposed three syntactic principles that governed the interpretation of different types of anaphoric expressions. Principle A stated that reflexive anaphors such as *himself* must have an structurally superior antecedent within their local syntactic domain (e.g. the smallest tensed clause containing the anaphor). Principle B states that nonreflexive pronouns must be free in the same domain. Principle C states that R-expressions (proper names and lexical NPs) cannot be bound. Chomsky's (1986) BT principles were purely syntactic. Subsequent theoretical work has questioned whether it is best to model these three principles as purely syntactic, with a range of approaches considering semantic, pragmatic, and morphological approaches to these constraints (Büring 2005; Levinson 1987; Pollard and Sag 1992; Reinhart and Reuland 1993; Reinhart 2006; Roelofsen 2010; Rooryck and van den Wyngaerd 2011; Schlenker 2005). Still, the constraints on interpretation of reflexives, pronouns, and R-expressions have been shown to be empirically robust for canonical examples as in (17/18; Gordon and Hendricks 1997).[8]

BT has had a substantial indirect influence on sentence processing research because it has played a central role in research that addresses the role that abstract, hierarchical

syntactic structure plays in guiding moment-by-moment processing decisions. During incremental processing, participants must identify antecedents for anaphors that they encounter. Many psychological models cast antecedent identification as a memory retrieval process: a pronoun accesses potential candidates from among the broader set of items active in memory (McKoon and Ratcliff 1980; Sanford and Garrod 1982).

Within this tradition many models characterized antecedent identification as a procedure that simultaneously accesses candidates via their morphological features alone (e.g. Sanford and Garrod 1982). Given restrictions on coreference as in (18), a basic feature-matching model is obviously too simplistic to account for speakers' ultimate coreference judgments. However, it is an empirical question whether such a simple model appropriately characterizes the operations of the processor at some intermediate stage of processing.

Against this background, grammatically informed psycholinguistic research has probed whether knowledge of grammatical constraints on coreference immediately affect the parser's earliest attempts to identify potential antecedents or how grammatical knowledge interacts with other sources of information. Nicol (1988) used the cross-modal priming technique to investigate what antecedents were reactivated upon processing a reflexive or an anaphor. In cross-modal priming experiments, participants are presented with an auditory stimulus that is interrupted by a lexical decision task at key points in the sentence. This technique can be used to evaluate what representations have been covertly activated at a given point in the sentence, by testing to see whether covertly activated representations convey a semantic priming effect on the lexical decision task. Nicol observed evidence that suggested that syntactically local antecedents were reactivated at the point of processing a reflexive, and all antecedents except syntactically local ones were reactivated at the point of processing a direct object pronoun (Nicol and Swinney 1989). This supported the conclusion that only Binding-compatible antecedents were activated at the point of processing a pronoun/reflexive.

Patrick Sturt later dubbed the view that Nicol and Swinney proposed the *Binding-as-initial-filter* hypothesis (2003a, 2003b). Since these early studies, there has been a vigorous debate over the evidence in favor of this view. For example, Badecker and Straub (2002) argued that Nicol and Swinney's experimental paradigm was not sensitive enough to distinguish the *Binding-as-initial-filter* view from the hypothesis that Binding constraints are deployed as one constraint among many on the interpretation of an anaphor (see e.g. Kaiser and Trueswell, 2004). Using self-paced reading, Badecker and Straub (2002) showed that binding inaccessible antecedents interfere with the processing of pronouns and reflexives, which is unexpected if Binding is deployed as a hard filter on interpretations from the earliest get-go. They concluded that the multiple constraints proposal is most likely correct for the processing of pronouns subject to Principle B: Binding theoretic constraints are deployed as one constraint among many on interpretation. This claim remains controversial (Bui and Dillon 2019; Chow, Lewis and Phillips 2014; Clifton, Kennison and Albrecht 1997). For reflexives, 2003 showed using eye-tracking-while-reading that Binding Principle A might more appropriately be characterized as a *defeasible* constraint on interpretation. Sturt proposed that there were multiple stages of antecedent evaluation involved in processing a reflexive, and early stages involved the application of Principle A as a filter. In later stages of processing, comprehenders could consult aspects of the discourse, which is perhaps useful for

achieving interpretations of reflexives that are not subject to Principle A (so-called *logophoric* interpretations; Sturt 2003a, 2003b).

Debates over this point are ongoing in the sentence-processing literature. The claim that Principle A acts as a hard filter on initial interpretations has seen its share of support (Cunnings and Sturt 2014; Dillon et al. 2013; Dillon et al. 2014, Dillon 2014). However, evidence for early interference from non-Principle A accessible antecedents has accumulated, offering support for a range of multiple constraints models that deploy structural and semantic constraints on interpretation in parallel during the processing of reflexive forms (Jaeger, Mertzen, van Dyke and Vasishth 2019; Parker and Phillips 2017; Patil, Lewis, and Vasishth 2015; Sloggett 2017).

Outside of studies investigating the processing of pronouns and reflexives subject to Principles A and B, similar debates have played out in a range of different related contexts. Similar issues about the role of structural and semantic constraints in the analysis of pronouns has played out in research that investigates the processing of bound variable pronouns (Kush, Lidz, and Phillips 2015; Cunnings, Patterson and Felser 2015; Moulton and Han 2018; Kush and Eik 2019), readers' ability to access logophoric interpretations for reflexives (Burkhardt 2002; Foraker 2003; Runner et al., 2003, 2006; Sloggett 2017), the processing of crossover constraints in comprehension (Kush et al. 2017), and the processing of name-pronoun relations subject to Binding Principle C (Cowart and Cairns 1987; van Gompel and Liversedge 2003; Kazanina et al. 2007; Drummer et al. 2019).

In all of the studies just listed, there is an active, unresolved debate over the degree to which structural principles have priority in settling early interpretive preferences. This subliterature is a reflection of a broader debate that has characterized the field of sentence processing: does syntactic structure play a privileged role in early sentence analysis, as held by theories such as the GP theory (Frazier and Rayner 1982), or do comprehenders deploy syntactic and semantic constraints in parallel as they analyze the structure of their linguistic input (e.g. Trueswell et al. 1994)? The brief review above makes it clear that a parallel debate has sprung up around the processing of the Binding Principles: understanding the time course of their application is perhaps the central area where this core architectural question about the human sentence processor is playing out today. Moreover, insofar as the constraints on co-interpretation are ultimately best understood as *structural* in nature, the phenomena above provide a way of probing how incremental parsers encode the abstract linguistic structure necessary to support these inferences during incremental word-by-word processing (Kush 2013).

Finally, the body of work on anaphor resolution also highlights another way in which Chomsky's work has influenced psycholinguistics. Recall that Chomsky argued that the analysis of linguistic performance would proceed only as far as the study of linguistic competence permits. In the case of this literature, this seems to be true. Nearly all researchers agree that the incremental processing of anaphoric expressions involves direct application of the Binding constraints to constrain interpretation: the role of the grammar in incremental syntactic analysis is not up for serious debate. Instead, the debates in this literature focus on the question of *when* they apply, and *whether* they have a special prominence in the analysis of anaphoric expressions. In this sense, we see Chomsky's forecast in Aspects borne out: the Binding theory has served as the primary driving force in some of the most active debates on the role of syntactic structure in guiding incremental sentence interpretation in contemporary psycholinguistics.

19.5 Conclusion

We have shown in these three areas how grammatical analysis has been the basis of psycholinguistic theorizing, and grammatical research has identified important test cases that have led to refinements in our understanding of the parser's real-time operation. Nearly all of this grammatical work can be traced directly or indirectly to the program initiated by Chomsky.

Endnotes

1 A well-known example: In the 1960s and 1970s, experiments were devised to test the "psychological reality" of Transformational Grammar (TG). Researchers pursued the idea that sentences whose derivation involved more transformations should be more perceptually complex than those whose derivations required fewer transformations. They further assumed that the difference in global perceptual complexity should be visible in a general experimental measure (e.g. whole-sentence reaction times). This hypothesis was the so-called "Derivational Theory of Complexity" (DTC; Chomsky and Miller 1963). Though some early experiments yielded results that appeared compatible with the DTC (e.g. Miller and McKean 1964), later experiments found no correlation between transformational complexity and reaction times (e.g. Slobin 1966). As a result, some researchers rejected the idea of a direct correspondence between grammatical constructs and parsing operations (Fodor, Bever, and Garrett 1974; Townsend and Bever 2001), while others rejected transformational grammars in favor of formalisms that were supposedly more directly realizable (e.g. Bresnan 1978). There are a number of reasons why these conclusions are unnecessary. Even though the grammatical model that was tested at that time has few modern adherents, it's important to point out that the results do not force rejection of Chomsky (1965) grammar. The version of the DTC that was falsified represented a combination of a formal grammar and specific linking hypotheses (e.g. that the parser executed transformations serially at the end of a sentence *after* deriving the surface structure of the sentence). The results are equally compatible with the conclusion that (one or more of) the linking hypotheses were incorrect, but the grammar was adequate (for an excellent, detailed discussion of these issues see Berwick and Weinberg 1984, Chapter 2).

2 To quote Chomsky (1965) on this point: " … [the] generative grammar does not, in itself, prescribe the character or functioning of a perceptual model … " Chomsky (1965), p. 9

3 Note that the MA explanation is compatible, in principle, with *any* formalism under which the constituent structure of (4b) is less complex than (4a).

4 It is actually unclear to us whether rational models should be treated as alternatives to implemented incremental process models such as GP theory, or whether rational models simply provide a description of patterns at a higher level of abstraction that eschews questions of implementation.

5 Crain and Steedman (1985) showed that the referential context can reduce the strength of garden-path effects. Intuitively, people seem more likely to adopt the reduced relative clause reading of *the dog raced around the track* if the sentence is preceded by a context that makes the RC necessary to disambiguate.

   i. There were two dogs cavorting in the yard.
   ii. The dog raced around the track stumbled.

   The GP parser would argue that the first-pass parser is just as likely to choose the main clause analysis of *The dog raced* in (i) as in (1), but that this choice would be overridden by referential considerations in stage two.

6 Some recent work has tried to account for local coherence effects without positing a self-organizing parser (Gibson 2006; Bicknell, Levy and Demberg 2010).

7 The appropriate grammatical analysis of such constructions has been a matter of debate among competing grammatical formalisms (see Phillips and Wagers 2007 for an accessible overview of different analyses). For ease of exposition, we focus on the movement analysis, but all of the psycholinguistic effects that we discuss are compatible with the full range of formal analyses.

8 In the psycholinguistic literature, there has been considerable debate over the status of reflexives and anaphors in other syntactic environments (Cunnings and Sturt 2014; Keller and Asudeh 2001; Runner, Sussman and Tanenhaus 2003, 2006).

References

Altmann, G. T., and Y. Kamide. 1999. Incremental interpretation at verbs: Restricting the domain of subsequent reference. *Cognition* 73 (3): 247–264.

Anderson, J. R. 1990. *The Adaptive Character of Thought*. Hilldale, NJ: Lawrence Erlbaum Associates.

Chomsky, N. 1965. *Aspects of the Theory of Syntax*. Cambridge: MIT Press.

Fodor, J., T. G. Bever, and A. Garrett. 1974. *The Psychology of Language: An Introduction to Psycholinguistics and Generative Grammar*. New York: McGraw-Hill.

Badecker, W., and K. Straub. 2002. The processing role of structural constraints on interpretation of pronouns and anaphors. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 28 (4): 748.

Berwick, R. C., and A. Weinberg. 1984. *The Grammatical Basis of Linguistic Performance*. Cambridge: MIT Press.

Bever, T. G. 1970. The cognitive basis for linguistic structures. *Cognition and the Development of Language* 279 (362): 1–61.

Burkhardt, P. 2002. Logophors: looking outside of syntax. In *Proceedings of Console IX*, edited by M. Van Koppen, E. Thrift, E. J. v. d. Torre and M. Zimmermann, 14–27. Leiden: University of Leiden

Büring, D. 2005. *Binding Theory*. Cambridge: Cambridge University Press.

Chaves, R. P. 2013. An expectation-based account of subject islands and parasitism. *Journal of Linguistics* 49 (2): 285–327.

Chow, W. Y., S. Lewis, and C. Phillips. 2014. Immediate sensitivity to structural constraints in pronoun resolution. *Frontiers in Psychology* 5: 630.

Christianson, K., A. Hollingworth, J. F. Halliwell, and F, Ferreira. 2001. Thematic roles assigned along the garden path linger. *Cognitive Psychology* 42 (4): 368–407.

Clifton, C., S. M. Kennison, and J. E. Albrecht. 1997. Reading the words her, his, him: implications for parsing principles based on frequency and on structure. *Journal of Memory and Language* 36 (2), 276–292.

Cowart, W., and H. S. Cairns. 1987. Evidence for an anaphoric mechanism within syntactic processing: Some reference relations defy semantic and pragmatic constraints. *Memory and Cognition* 15 (4): 318–331.

Crain, S., and M. Steedman. 1985. On not being led up the garden path: the use of context by the psychological syntax processor. In *Natural Language Parsing: Psychological, Computational and Theoretical Perspectives*, edited by D. Dowty, L. Karttunen and A. Zwicky, 320–538. New York: Cambridge University Press.

Cunnings, I., C. Patterson, C, and C. Felser. 2015. *Structural constraints on pronoun binding and coreference: evidence from eye movements during reading. Frontiers in Psychology*, 6: 840.

Cunnings, I., and P. Sturt. 2014. Coargumenthood and the processing of reflexives. *Journal of Memory and Language* 75: 117–139.

Dillon, B. 2014. Syntactic memory in the comprehension of reflexive dependencies: an overview. *Language and Linguistics Compass* 8 (5): 171–187.

Dillon, B., W. Y. Chow, M. Wagers, T. Guo, F. Liu, and C. Phillips. 2014. The structure-sensitivity of memory access: evidence from Mandarin Chinese. *Frontiers in Psychology* 5: 1025.

Dillon, B., A. Mishler, S. Sloggett, and C. Phillips. 2013. Contrasting intrusion profiles for agreement and anaphora: Experimental and modeling evidence. *Journal of Memory and Language* 69 (2): 85–103.

Erteschik-Shir, N. 1981. More on extractability from quasi-NPs. *Linguistic Inquiry* 12 (4): 665–670.

Ferreira, F. 2003. The misinterpretation of noncanonical sentences. *Cognitive Psychology* 47 (2): 164–203.

Ferreira, F., K. Christianson, and A. Hollingworth. 2001. Misinterpretations of garden-path sentences: Implications for models of sentence processing and reanalysis. *Journal of psycholinguistic research* 30 (1): 3–20.

Fiebach, C. J., M. Schlesewsky, and A. D. Friederici. 2002. Separating syntactic memory costs and syntactic integration costs during parsing: The processing of German wh-questions. *Journal of Memory and Language* 47 (2): 250–272.

Fodor, J. D. 1978. Parsing strategies and constraints on transformations. *Linguistic Inquiry* 9 (3): 427–473.

Fodor, J. A. 1983. *The Modularity of Mind*. Cambridge: MIT Press.

Foraker, S. 2003. The processing of logophoric reflexives shows discourse and locality constraints. In *Proceedings from the Annual Meeting of the Chicago Linguistic Society 39*, 295–309. Chicago: Chicago Linguistic Society.

Frazier, L. 1985. Syntactic complexity. *In Natural Language Parsing: Psychological, Computational and Theoretical Perspectives*, edited by D. Dowty, L. Karttunen, and A. Zwicky, 129–189. New York: Cambridge University Press.

Frazier, L. 1987. Syntactic processing: evidence from Dutch. *Natural Language and Linguistic Theory* 5 (4): 519–559.

Frazier, L., and K. Rayner. 1982. Making and correcting errors during sentence comprehension: Eye movements in the analysis of structurally ambiguous sentences. *Cognitive Psychology* 14 (2): 178–210.

Garrett, M. F. 1975. The analysis of sentence production. In *Psychology of Learning and Motivation, Volume* 9, edited by G. H. Bower, 133–177. New York: Academic Press.

Gibson, E. 1998. Linguistic complexity: Locality of syntactic dependencies. *Cognition* 68 (1): 1–76.

Gordon, P. C., and R. Hendrick. 1997. Intuitive knowledge of linguistic co-reference. *Cognition* 62 (3): 325–370.

Gouvea, A. C., C. Phillips, N. Kazanina, and D. Poeppel. 2010. The linguistic processes underlying the P600. *Language and cognitive processes* 25 (2): 149–188.

Hale, J. 2014. *Automaton theories of human sentence comprehension*. Stanford, CA: CSLI Publications.

Hofmeister, P., L. S. Casasanto, and I. A. Sag. 2013. Islands in the grammar? Standards of evidence. In *Experimental Syntax and Island Effects*, edited by J. Sprouse and N. Hornstein, 42–63. Cambridge: Cambridge University Press.

Kaan, E., A. Harris, E. Gibson, and P. Holcomb. 2000. The P600 as an index of syntactic integration difficulty. *Language and Cognitive Processes* 15 (2): 159–201.

Kaiser, E., and J. C. Trueswell. 2004. The role of discourse context in the processing of a flexible word-order language. *Cognition* 94 (2): 113–147.

Kazanina, N., E. F. Lau, M. Lieberman, M. Yoshida, and C. Phillips. 2007. The effect of syntactic constraints on the processing of backwards anaphora. *Journal of Memory and Language* 56 (3): 384–409.

Kluender, R., and M. Kutas. 1993. Bridging the gap: Evidence from ERPs on the processing of unbounded dependencies. *Journal of Cognitive Neuroscience* 5 (2): 196–214.

Kuno, S. 1987. *Functional Syntax: Anaphora, Discourse, and Empathy*. Chicago: University of Chicago Press.

Kush, D. W. 2013. *Respecting relations: Memory access and antecedent retrieval in incremental sentence processing*. Doctoral dissertation, University of Maryland.

Kush, D. W., and R. Eik. 2019. Antecedent accessibility and exceptional covariation: Evidence from Norwegian Donkey Pronouns. *Glossa: A Journal of General Linguistics* 4 (1): 96.

Kush, D., J. Lidz, and C. Phillips. 2015. Relation-sensitive retrieval: evidence from bound variable pronouns. *Journal of Memory and Language* 82*:* 18–40.

Kush, D., J. Lidz, and C. Phillips. 2017. Looking forwards and backwards: the real-time processing of Strong and Weak Crossover. *Glossa* 2 (1): 70.

Levinson, S. C. 1987. Pragmatics and the grammar of anaphora: A partial pragmatic reduction of binding and control phenomena. *Journal of Linguistics* 23 (2): 379–434.

Levy, R. 2008. Expectation-based syntactic comprehension. *Cognition* 106 (3): 1126–1177.

MacDonald, M. C. 1993. The interaction of lexical and syntactic ambiguity. *Journal of Memory and Language* 32 (5): 692–715.

McRae, K., M. J. Spivey-Knowlton, and M. K. Tanenhaus. 1998. Modeling the influence of thematic fit (and other constraints) in on-line sentence comprehension. *Journal of Memory and Language* 38 (3): 283–312.

Miller, G.A., 2003. The cognitive revolution: a historical perspective. *Trends in Cognitive Sciences* 7 (3): 141–144.

Miller, G. A., and N. Chomsky. (1963). Finitary models of language users. In *Handbook of Mathematical Psychology*, edited by D. Luce. R. R. Bush and E. Galanter, 419–491. New York and London: John Wiley and Sons Inc.

Miller, G. A., and K. O. McKean. 1964. A chronometric study of some relations between sentences. *Quarterly Journal of Experimental Psychology* 16 (4): 297–308.

Moulton, K., and C. H. Han. 2018. C-command vs. scope: An experimental assessment of bound-variable pronouns. *Language* 94 (1): 191–219.

Nicol, J., and D. Swinney. 1989. The role of structure in coreference assignment during sentence comprehension. *Journal of Psycholinguistic Research* 18 (1): 5–19.

Phillips, C. 2006. The real-time status of island phenomena. *Language* 82 (4): 795–823.

Phillips, C., N. Kazanina, and S. H. Abada. 2005. ERP effects of the processing of syntactic long-distance dependencies. *Cognitive Brain Research* 22 (3): 407–428.

Phillips, C., and M. Wagers. 2007. Relating structure and time in linguistics and psycholinguistics. In *Oxford Handbook of Psycholinguistics*, edited by M. Gareth Gaskell, 739–756. Oxford: Oxford University Press.

Phillips, C., M. W. Wagers, and E. F. Lau. 2011. Grammatical illusions and selective fallibility in real-time language comprehension. In *Experiments at the Interfaces*, edited by J. Runner, 147–180. Bingley, UK: Emerald.

Pollard, C., and I. A. Sag. 1992. Anaphors in English and the scope of binding theory. *Linguistic inquiry* 23 (2): 261–303.

Reinhart, T. (2006). *Interface Strategies: Optimal and Costly Computations*. Cambridge: MIT Press.

Reinhart, T., and E. Reuland. 1993. Reflexivity. *Linguistic Inquiry* 24 (4): 657–720.

Roelofsen, F. 2010. Condition B effects in two simple steps. *Natural Language Semantics* 18 (2): 115–140.

Rooryck, J., and G. J. Vanden Wyngaerd. 2011. *Dissolving Binding Theory*. Oxford: Oxford University Press.

Ross, J. R. 1967. *Constraints on variables in syntax*. Doctoral dissertation: MIT.

Runner, J. T., R. S. Sussman, and M. K. Tanenhaus. 2003. Assignment of reference to reflexives and pronouns in picture noun phrases: evidence from eye movements. *Cognition* 89 (1): B1–B13.

Runner, J. T., R. S. Sussman, and M. K. Tanenhaus. 2006. Processing reflexives and pronouns in picture noun phrase. *Cognitive Science* 30 (2): 193–241.

Sanford, A. J., and S. C. Garrod. 1982. Towards a processing account of reference. *Advances in psychology* 8: 100–110.

Sanford, A. J., and P. Sturt. 2002. Depth of processing in language comprehension: Not noticing the evidence. *Trends in Cognitive Sciences* 6 (9): 382–386.

Schlenker, P. 2005. Non-redundancy: Towards a semantic reinterpretation of binding theory. *Natural Language Semantics* 13 (1): 1–92.

Shepard, R. N. 1987. Toward a universal law of generalization for psychological science. *Science* 237 (4820): 1317–1323.

Slattery, T. J., P. Sturt, K. Christianson, M. Yoshida, F. Ferreira. 2013. Lingering misinterpretations of garden path sentences arise from competing syntactic representations. *Journal of Memory and Language* 69 (2): 104–120.

Sloggett, S. 2017. *When errors aren't: How comprehenders selectively violate Binding Theory*. Doctoral dissertation, University of Massachusetts Amherst.

Spivey, M. J., and M. K. Tanenhaus. 1998. Syntactic ambiguity resolution in discourse: Modeling the effects of referential context and lexical frequency. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 24 (6): 1521–1543.

Sprouse, J., M. Wagers, and C. Phillips. 2012a. A test of the relation between working-memory capacity and syntactic island effects. *Language* 88 (1): 82–123.

Sprouse, J., M. Wagers, and C. Phillips. 2012b. Working-memory capacity and island effects: A reminder of the issues and the facts. *Language* 88 (2): 401–407.

Stowe, L. A. 1986. Parsing Wh-constructions: Evidence for on-line gap location. *Language and Cognitive Processes* 1 (3): 227–245.

Sturt, P. 2003. The time-course of the application of binding constraints in reference resolution. *Journal of Memory and Language* 48 (3): 542–562.

Swets, B., T. Desmet, C. Clifton, and F. Ferreira. 2008. Underspecification of syntactic ambiguities: Evidence from self-paced reading. *Memory and Cognition* 36(1): 201–216.

Tabor, W., B. Galantucci, and D. Richardson. 2004. Effects of merely local syntactic coherence on sentence processing. *Journal of Memory and Language* 50 (4): 355–370.

Tabor, W., and S. Hutchins. 2004. Evidence for self-organized sentence processing: Digging-in effects. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 30 (2): 431–450.

Tanenhaus, M. K., Spivey-Knowlton, M. J., Eberhard, K. M., and Sedivy, J. C. 1995. Integration of visual and linguistic information in spoken language comprehension. *Science* 268 (5217): 1632–1634.

Tenenbaum, J. B., and T. L. Griffiths. 2001. Generalization, similarity, and Bayesian inference. *Behavioral and Brain Sciences* 24 (4): 629–640.

Townsend, D. J., and T. G. Bever. 2001. *Sentence Comprehension: The Integration of Habits and Rules*. Cambridge: MIT Press.

Traxler, M. J., and M. J. Pickering. 1996. Plausibility and the processing of unbounded dependencies: An eye-tracking study. *Journal of Memory and Language* 35 (3): 454–475.

Trueswell, J. C., M. K. Tanenhaus, and S. M. Garnsey. 1994. Semantic influences on parsing: Use of thematic role information in syntactic ambiguity resolution. *Journal of Memory and Language* 33 (3): 285–318.

Van Gompel, R. P., and S. P. Liversedge. 2003. The influence of morphological information on cataphoric pronoun assignment. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 29 (1): 128–139.

20

Neuroscience and Syntax

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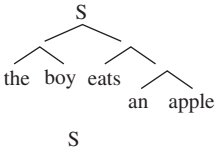
20.1 Introduction

The neuroscience of language studies the relationship between linguistic phenomena and the structure and functioning of the human brain. Neurolinguists combine insights from linguistic theory with experimental methodologies coming from cognitive neuroscience and biomedical research, to explore how language and the brain map onto each other at the neuroanatomical level. In this chapter, we focus on the neural basis supporting the remarkable human capacity to effortlessly assemble single words into more complex hierarchical structures, thus enabling the production and comprehension of unbounded arrays of different linguistic expressions.

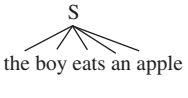
A detailed characterization of the fundamentally hierarchical nature of human language has been already at the heart of linguistic theory since the advent of the generative enterprise in the second half of the previous century. A major objective within the generative framework has been to make humans' knowledge of grammar explicit, that is distinguishing grammatical from ungrammatical sequences by showing how relations between linear sequences of words (expressed as assemblies of sounds, characters, or signs) result from more abstract structural relations in the human mind. In this sense, linguistic expressions consist of hierarchical grouping relations which cannot be determined solely by the linear order of elements. Consider the sentence in (1), which can be represented either as a hierarchical tree in (2), or as a flat structure in (3):

(1) The boy eats an apple

(2)



(3)



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Empirical tests on tree structures like (2) and (3) exist, which can be used to assess the superiority of hierarchy over linearization, by showing that some sequences of words behave as units when certain syntactic manipulations are applied to the sentence (see "constituent analysis"; Harris 1946; Nida 1948; Pike 1943; Wells 1947). For example, a syntactic unit like *an apple* in (4) can be focus in a cleft construction in (5), while non-units, like *apple in* cannot in (6):

(4) The boy eats an apple in the park
(5) It is an apple that the boy eats __ in the park
(6) *It is apple in that the boy eats an __ the park

The absence of any intermediate phrasal level between single words and the sentence node in (3) above would not be able to predict the possibility of dislocating units within the sentence, nor any asymmetry between (5) and (6). The discovery that certain relations (e.g., c-command; Reinhart 1976) regulate binding between distinct units in the sentence (e.g., anaphors and antecedents) according to pervasive structure-dependent principles has considerably strengthened the hierarchically-based hypothesis for language expressions.

Developments within the generative framework in the last decades have concentrated on the precise characterization of the mechanism enabling hierarchical structures to be generated. In this respect, the hypothesis is put forward that human beings must be endowed with some biologically determined, species-specific, universal computational mechanism (Lenneberg 1969). This mechanism, now called *Merge*, generates all possible hierarchical expressions of human language, by recursively assembling words into more complex syntactic objects (Chomsky 1995; Everaert et al. 2015; Friederici et al. 2017; Hauser, Chomsky, and Fitch 2002). *Merge* can be defined as a very simple combinatorial mechanism bringing two syntactic units together to recursively form new syntactic sets (7–8):

(7) $xy \rightarrow \{xy\}$
(8) $z\{xy\} \rightarrow \{z\{xy\}\}$

The syntactic category of the newly formed sets is assigned according to the labels of the items within the unit (9):

(9) $xy \rightarrow k_x\{xy\}$

Merge is taken to be intimately connected to the internal system of thought, independent of the sensory-motor system which externalizes thoughts via linear sequences of sounds, signs, or written characters (Chomsky 1995; Berwick et al. 2013).

Overall, early attempts within the generative framework to formalize the syntactic knowledge of language as the product of a biologically determined capacity present in all human beings has led to a deeper understanding of some of the key components of human language. More recent developments within the research program have promoted a significant shift toward a more biologically plausible

perspective on language (see Alexiadou and Lohndal, Chapter 3 this volume). Thus, these formalisms – although not exempt from critical opposing views (see the debate in *Natural Language and Linguistic Theory*: Holmberg 2000; Lappin, Levine, and Johnson 2000b, 2000a, 2001; Piattelli-Palmarini 2000; Reuland 2000; Roberts 2000; Uriagereka 2000) – have encouraged linguistics to seek integration with other sciences, including neuroscience, by putting forward possible testable models of language processing in the human mind (de Zubicaray and Schille 2019). The gradual emergence of noninvasive neuroimaging techniques investigating the structure and function of the human brain – electroencephalography (EEG), magnetoencephalography (MEG), functional/structural magnetic resonance imaging ([f]MRI) – has in turn opened to the possibility of validating such models, by looking for possible integration points between formal descriptions of human syntax and underlying neurobiological systems.

Moving from early lesion studies (Zurif, Caramazza, and Myerson 1972), the effort to test hypotheses about our abstract syntactic knowledge with neuroscientific methods has made it possible to begin evaluating the neurobiological validity of number of core aspects of human syntax – although a complete one-to-one correspondence between linguistic computations and neural processes might still be missing (Poeppel and Embick 2013). These include the testing of universal principles of grammar (Musso et al. 2003), the neural adherence to hierarchical constituency (Pallier, Devauchelle, and Dehaene 2011), the brain localization of recursive mechanisms for phrase-structure grammars (Friederici et al. 2006), and the neural response to basic structure-building computations under *Merge* (Zaccarella and Friederici 2015; Zaccarella et al. 2015). Current additional directions comprise the way the brain uses distinct cortical timescales to track compositional processing from words to sentences during language comprehension (Ding et al. 2016). At the phylogenetic level, the formalization of a possible computational syntactic system generating hierarchical linguistic structures has further enabled researchers to test the degree of species-specificity of language across human and nonhuman primates behaviorally (Hauser, Chomsky, and Fitch 2002), and with respect to their brains' function and structure (Milne et al. 2016; Milne, Petkov, and Wilson 2018; Wilson et al. 2015; Wilson et al. 2013) while at the same time enabling the comparison of the structural pathways subserving syntactic processing in the human brain with those found in the brains of nonhuman primates (Rilling et al. 2008).

The course of action in this chapter is as follows: We begin with a brief discussion of language as a biological system that includes a historical sketch of our understanding of language in the brain (Section 20.2). We continue with an overview of the early days of brain-syntax research in neuropsychology, primarily on the basis of lesion studies (Section 20.3). Next, we discuss some current insights on the neurobiological basis of syntactic computations in the adult brain derived from functional and structural imaging studies carried out in the past decades (Section 20.4 and Section 20.5). These results provide a more fine-grained picture of the core left-hemispheric networks involved in syntactic processing. An illustration of the structural correlates of syntactic abilities in ontogeny and phylogeny will follow (Sections 20.6 and 20.7). We end with a short summary of our discussion and a reflection on the impact that Noam Chomsky's ideas have had on the neuroscience of language.

20.2 Language as a Biological System

The link between language and the left hemisphere of the human brain was first established in 1836 by Marc Dax, a French neurologist who wrote a note about speech disturbance and left hemispherical lesions (published as Dax 1863; Dax 1865), 25 years before Paul Broca's more famous description of a patient whose lesion in the left inferior frontal cortex led to an arrest of speech (so-called aphemia; Broca 1861). Broca did not dissect the brains of his patients; therefore, he was not able to know that their lesions extended far into neighboring regions and the white matter (Dronkers et al. 2007). The posterior portion of the inferior frontal gyrus was soon termed Broca's area (Figure 20.1) and early language models considered it a speech-related brain region primarily supporting language production (Green 1970; Goodglass, Gleason, and Hyde 1970; Weigl and Bierwisch 1970). Further lesion studies associated the left superior temporal gyrus with language comprehension abilities (Wernicke 1874). Jointly, these observations gave rise to the Wernicke-Lichtheim-Geschwind (WLG) model of the neurobiology of language in which Broca's area subserves language production and so-called Wernicke's area (roughly left posterior superior temporal gyrus) enables language comprehension (Geschwind 1970; Lichtheim 1884). Although the WLG model correctly identified two major nodes in the language network, the model's anatomical assertions are nowadays severely underspecified, with incorrect functional attributions and impoverished linguistic description (Friederici 2011; Hagoort 2014; Tremblay and Dick 2016; but see Matchin and Hickok 2019, for an updated neural model that includes a neuroanatomical distinctions between language comprehension and production).

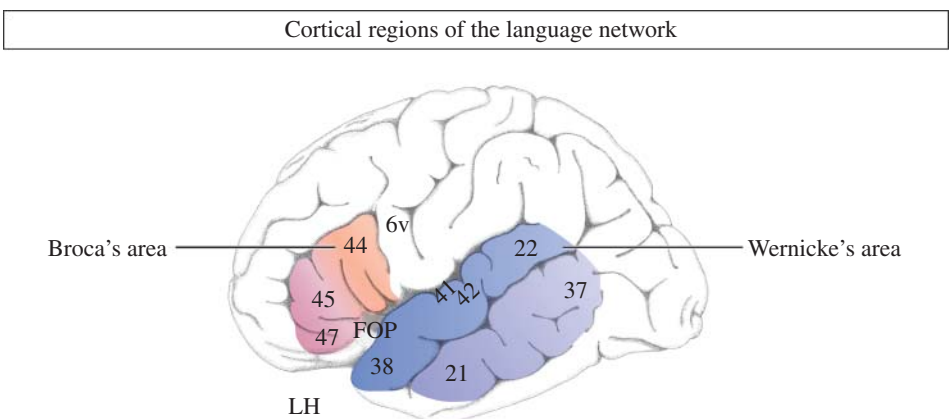


Figure 20.1 Cortical regions of the language network. Left hemispherical (LH) view of the human brain. Broca's area is located in the inferior frontal gyrus (IFG) and it is composed by Brodmann area (BA) 44 and BA 45. Additional classical regions in the IFG are the frontal operculum (FOP) and BA 47. Wernicke's region is located in the posterior temporal cortex (pTC). Cortical regions involved in language processing in the temporal cortex are the primary auditory cortex (BA 41/BA 42), the superior temporal gyrus (STG) (BA 22), the middle temporal gyrus (MTG) (BA 21) and BA 37, as well as the anterior temporal pole (BA 38)

20.3 The Early Days: Neuropsychological Evidence for Syntax in the Brain

Before the advent of functional neuroimaging, studying patients with brain lesions as well as patients undergoing neurosurgical interventions such as, for example, a corpus callosotomy (i.e. a split-brain operation) were the only way in which relationships between brain structure and cognitive functions could be established. Patients provided researchers with "natural experiments" that made it possible to draw inferences regarding the cognitive function supported by the destroyed tissue, given a patient's observed behavioral deficit or lack thereof due to a vascular disease (stroke), a brain contusion (accident) or after a surgical intervention. In line with the ideas of the WBL model mentioned above, traditional classifications of aphasic syndromes pay little attention to linguistic theory and instead tend to classify patients with regard to the loss of their language production or comprehension abilities. The loss or deficit of language production abilities is usually termed Broca's aphasia, whereas the loss or deficit of language comprehension abilities is labeled Wernicke's aphasia. We will here strictly focus on studies that are relevant to the neuroscience of syntax and abstain from discussing aphasiology and aphasic syndromes in any detail (see Raymer and Rothi 2015 for a general overview).

Zurif, Caramazza, and Myerson (1972) were the first to suggest that the aphasic syndrome leading to Broca's aphasia was not merely a language-production or speech-related deficit, as suggested by the WBL model in which Broca's area subserves language production and Wernicke's area supports language comprehension. Following linguistic theorizing of language competence to be distinct from performance, Zurif and colleagues reasoned that a competence deficit should affect performance both in production and comprehension. In their seminal work, the authors used a grammatical judgment task asking patients classified as Broca's aphasics – a subgroup of which usually exhibit behavior that is labeled as *agrammatic* in the literature – to sort words from a set of sentences on the basis of how closely related they thought the words would be. Zurif and colleagues found that the structures that the aphasic patients sorted excluded almost systematically all those grammatical elements (function words) that were not necessary part of the intrinsic meaning of the sentence, while retaining major lexical items. The authors thus concluded that "since the agrammatic aphasic's tacit knowledge of English syntax appears to be as restricted as is his use in syntax, we may presume that agrammatism reflects a disruption of the underlying language mechanism." Caramazza and Zurif (1976) tested Broca's aphasics' comprehension further, using center-embedded sentences that could be correctly understood either on the basis of semantic constraints ("the apple that the boy is eating is red"; semantically, only the boy can eat the apple, not vice versa), or on the basis of syntactic relationships among words ("the man that the woman is hugging is happy"; semantically, both the man and the woman can hug the other, while syntactically, only the woman can hug the man). Again, the authors found that Broca's aphasics performance dropped to chance when they had to use syntactic information. Thus, they proposed that these patients suffered from an impairment specifically related to "syntactic-like cognitive operations" in language comprehension *and* production caused by damage to the brain's "anterior language area" (i.e. Broca's area). A similar point of view was echoed by Friederici (1981) and Friederici, Schönle, and Garrett (1982) who asserted that the

deficit in agrammatic Broca's aphasics can be described as the inability of patients to assign syntactic structure.

The repeated association of agrammatic Broca's aphasia with frontal lesions led Grodzinsky (2000) to eventually put forward the so-called trace-deletion hypothesis. This hypothesis constituted a first attempt at establishing explicit links between an aphasic syndrome (Broca's aphasia), a brain region (Broca's area), and a specific linguistic theory (Government-and-Binding [GB] theory; Chomsky 1988). More precisely, the central claim of the trace-deletion hypothesis was that Broca's area implements cognitive functions that relate to the movement of phrasal constituents, but only with regard to noun phrases and *wh*-phrases, excluding head-movement. Grodzinsky thus considered the impairment of Broca's aphasics to be related to one very particular aspect of linguistic theory, whereas the general ability to build phrases or for syntactic processing construed more broadly was thought be preserved in these patients.

While recent developments within the Minimalist framework challenge the trace-deletion hypothesis at the theoretical level (Nunes 2011), the very coarse neuroanatomical precision of the lesion areas due to vascular diseases is a general downside of aphasia studies. Moreover, the notion of Broca's area has been defined in many different ways by different researchers (Tremblay and Dick 2016). Today, Broca's area is understood to be neither cytoarchitectonically nor functionally homogenous (Amunts and Zilles 2012; Goucha and Friederici 2015; Hagoort 2013; Hagoort and Indefrey 2014; Zaccarella, Schell, and Friederici 2017; Zilles and Amunts 2018). Against this background, the general observation that lesions are rarely focal and tend to encompass more than just one particular brain region becomes crucial. More recent work in aphasiology has tried to overcome some of these limitations using a so-called lesion-symptom mapping approach relying on the overlap of many individual lesions (for a review see Wilson 2017) but the general reservations still hold.

In sum, lesion studies have been a reliable tool for establishing first brain–behavior relationships, showing that syntactic abilities are lateralized and, to an extent, depend on the posterior portion of the inferior frontal gyrus in the language dominant hemisphere. But mapping linguistic computations onto neural circuitry requires an approach that captures the computational machinery of the human language faculty in more parsimonious and generic (i.e. Minimalist) terms and, at the same time, provides a much more fine-grained assessment of the involved neural structures on the neuroscientific side. The advent of structural and functional neuroimaging has provided researchers with a tool capable of obtaining such fine-grained data which we can attempt to link to linguistic computations.

20.4 Functional Imaging of Syntactic Computations

A great number of studies across different experimental manipulations in different languages and modalities have been testing the neuroanatomical reality of the syntactic component, by specifically looking at:

- Universal principles of grammar by means of possible and impossible syntactic rules
- The brain's adherence to hierarchical constituency
- Movement

- Degree of recursion
- The *Merge* computation

Overall, syntactic processing appears to be strongly localizable in the left hemisphere, including Broca's area, and specifically in BA 44, the posterior superior temporal gyrus (pSTG) and the superior temporal sulcus (pSTS; Friederici 2011; Hagoort and Indefrey 2014; Zaccarella, Schell, and Friederici 2017). Here, we discuss some representative functional studies testing syntax in the brain. This list of studies is by no means intended to be exhaustive, but it tries to broadly cover some of the most central issues on natural language syntax tested using functional imaging in the mature brain.

In a seminal study comparing possible and impossible grammars, Musso and colleagues had German native speakers learn sets of grammatical rules of the Italian and the Japanese languages that could either be real or unreal in the sense that they would violate general syntactic principles of human grammar (Musso et al. 2003). Subjects would either learn a language that, for example, used lexical elements from real Italian and required a linguistic parameter setting different from the subjects' native German (e.g., the null-subject parameter: *Mangio la pera.*, literally "eat the pear" with the meaning "I eat the pear"), or a language that used lexical elements from real Italian but relied on an impossible rule (e.g., negation being established by arbitrarily emphasizing a specific linear position of a word in the sequence instead of using hierarchy: *Paolo mangia la no pera.*, literally "Paolo eats the no pear"). The authors report a change of activation in Broca's area throughout the course of the functional neuroimaging study, with an increase of activation in later runs (when, presumably, subjects have mastered novel rules) relative to earlier runs (when, presumably, subjects are still learning the rules). Critically, this increase only occurred for languages with rules that agreed with structure-dependent rules of Universal Grammar as posited in generative grammar, and not for languages with rules that depended on linear order and not structure. The same patterns of data in Broca's area had also been reported when different stimuli and population samples were tested, still manipulating real and impossible syntactic rules (Tettamanti et al. 2002).

The neural adherence to hierarchical constituency has first been tested by Pallier and colleagues using fMRI to measure neural activity correlating with constituent size of linguistic structures (Pallier, Devauchelle, and Dehaene 2011). Specifically, subjects were asked to read sequences of 12 words or pseudowords, which could form constituents of 12-word length ("I believe that you should accept the proposal of your new associate"), or being decomposed in smaller constituents of reduced size, like 6 ("the mouse that eats our cheese; two clients examine this nice couch"), 4, 3, or 2 while lying in the scanner. The authors found a set of areas in the left posterior temporal and inferior frontal regions, including Broca's area, showing constituent size effects regardless of whether the constituents were formed by real content words, or whether they were replaced by pseudowords. This suggests that these areas are able to access abstract syntactic frames to build well-formed constituent structures, even in the absence of semantic meaning. On the other hand, regions in the temporal pole, anterior superior temporal sulcus and temporo-parietal junction showed constituent size effect only in the presence of real content words.

The linguistic concept of *movement* describes word order permutations by having discontinuous constituents or displacements within a sentence (see Nunes 2011 for a re-definition of movement in Minimalist terms). A study by Ben-Shachar et al. (2003)

in Hebrew and found that movement could be localized in the left inferior frontal gyrus (i.e. Broca's area) and in the pSTS and suggested that the structural analysis of sentences containing syntactic movement may take place in Broca's area, while access to predicate argument structure might occur in the left pSTS. Friederici et al. (2005) showed that the activation in the posterior portion of Broca's area (BA 44) parametrically increased as the number of moved constituents increased. In this study, activation was also found in the presupplementary motor area though this activation did not change with the number of moved constituents.

Functional studies on recursion have been motivated by the attempt to test how the human brain might handle grammars of increasing generative power, ranging from low-level AB^n finite-state grammars (FSG) based on transitional probabilities, to more complex A^nB^n phrase-structure grammars (PSG) that can generate structures of natural human languages. In one first artificial grammar fMRI experiment, Friederici and colleagues could show that the two grammars are supported by different areas in the human brain, such that the FSG processing is subserved by the left frontal operculum, while the posterior portion of Broca's area (BA 44), a phylogenetically younger cortical area, appears to be specifically active during the computation of PSG dependencies (Friederici et al. 2006). In a second experiment using a natural grammar and German sentences as stimuli, PSG rules generating double-embedding structures ("Maria, [die Hans, [der gut aussah], liebte], Johan geküsst hatte"*; Maria who loved Hans who was good looking kissed Johan*) also revealed activation in BA 44 driven by syntactic complexity operationalized as the number of embedded sentences (Makuuchi et al. 2009). The latter study in contrast to the former study, using natural meaningful sentences, additionally activated the posterior superior temporal cortex (Friederici et al. 2009).

In recent years, different imaging studies have begun to reduce stimulus complexity to very basic two or three-word levels to determine the localization of single applications of *Merge* in the human brain (Schell, Zaccarella, and Friederici 2017; Zaccarella and Friederici 2015; Zaccarella et al. 2015). By using determiner phrases with very reduced conceptual content consisting of a function word and a pseudoword ("Dieser Flirk"; *This flirk*), it was possible to localize *Merge* in a very confined subpart of the most anterior-ventral BA 44 with little variance across subjects. List strings without any function word, in contrast, only involved the frontal operculum/anterior insula (Zaccarella and Friederici 2015) – a phylogenetically older part of the cortex (Sanides 1962; Amunts and Zilles 2012). Thus, these results converge on the idea that specific neural populations of BA 44 are especially active during *Merge* application, be it at very basic levels or more complex ones, also in the absence of semantic information (Goucha and Friederici 2015).

To note, converging evidence for the existence of a neural syntactic component building-up hierarchical linguistic structures can be finally found in recent neurocognitive approaches using online parsing information metrices that aim to test neural behavior correlating with linguistic competence during actual performance (Brennan 2016). First studies report that hierarchy-based parsing models (Brennan et al. 2016; Nelson et al. 2017; Bhattasali et al. 2019; Brennan and Hale 2019; see also Ding et al. 2016 and Martin and Doumas 2017) outperform linear-based models (for a discussion on linear-based models, see Frank and Yang 2018; Frank and Christiansen 2018; Frank, Bod, and Christiansen 2012; McDonald and Shillcock 2003) in explaining

unique variance in neural activation within the cortical language network during natural language processing, notwithstanding distinct temporal resolutions and different methodologies employed.[1]

20.5 Functional and Structural Connections of the Syntactic Network

At the functional level, methods of analysis estimating the directionality of information flow between specific regions during experimental stimulation (Dynamic Causal Modeling, DCM; Friston, Harrison, and Penny 2003) has made it possible to observe how regions active for syntactic tasks might co-work during phrase structure building. One first study found that syntactic complexity – operationalized as complex object-cleft vs. less complex subject-cleft sentences – appears to be primarily processed in the IFG – which acts as a pure syntactic processor – and then sent to the pSTS/STG, which seems to rather support verb argument structure (den Ouden et al. 2012). The centrality of the IFG as the driving input for syntax has been confirmed by further studies using either complex object-first sentences (Makuuchi and Friederici 2013) , or very simple two-word phrases (Wu, Zaccarella, and Friederici 2019), thus suggesting

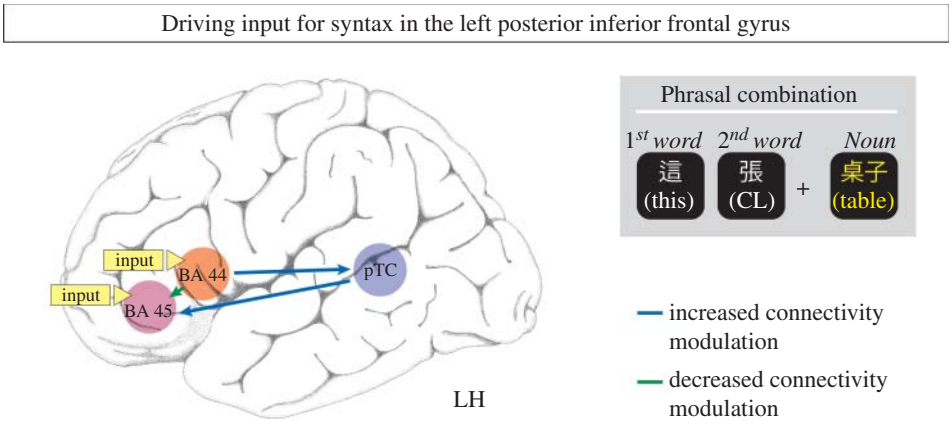


Figure 20.2 Driving input for syntax in the left posterior inferior frontal gyrus. Functional modulations of the linguistic network during the processing of simple phrases in Chinese. The driving input in left BA 44 and 45 indicates that the IFG takes over syntactic and semantic information processing at the initial state of word recognition in Chinese. The connection from BA 44 to BA 45 is strongly inhibited during the processing of syntactically grammatical sequences, suggesting that BA 44 inhibits semantic information processing in BA 45 to resolve the phrase structures (green arrow). The strong modulations in the connections from BA 44 to the posterior temporal cortex (pTC) and from pTC to BA 45 reflect lexico-semantic integration processing. *Source*: Adapted from Wu, Zaccarella and Friederici, (2019)

IFG's primary role in phrase structure building independently of hierarchical complexity (Figure 20.2). Worth noting is the observation that activity in BA 44 and in the pSTS/STG during language experiments have been found to correlate with each other already when modulatory effects driven by linguistic manipulations are removed from the signal, indicating the existence of a basic network acting as a general framework for language processing (Lohmann et al. 2010).

At the structural level, diffusion tensor imaging (DTI) has made it possible to identify structural connections between brain regions in vivo (Catani and Thiebaut de Schotten 2008), thus revealing distinct dorsal and ventral white matter fiber bundles connecting the inferior-frontal with posterior temporal regions (Figure 20.3). The dorsal pathway linking the posterior Broca's area (BA 44) with the posterior temporal cortex via the arcuate fascicle has been demonstrated to correlate with the ability to perform syntactic processes (Friederici et al. 2006; Skeide and Friederici 2016; Wilson et al. 2011). Further evidence in this respect comes from structural data based on probabilistic tractography, which show that the activation peak in BA 44 obtained from the PSG artificial grammar paradigm based on nonadjacent hierarchical dependences (A^nB^n) connects with the pSTG along the dorsal pathway. Results from DTI-based tractography propose that the ventral pathway linking BA 47 and anterior Broca's area (BA 45) to the temporal cortex via the extreme fiber capsule system rather supports semantic processing (Saur et al. 2008).

Overall, the precise neuroanatomical characterization of the linguistic network implementing syntax makes it possible to ask whether this network is already present at birth and how it develops during maturation (ontogeny), as well as whether this network is present in the brains of nonhuman primates and how it evolved (phylogeny). These neuroscientific questions are directly related to Chomsky's insight that crucial aspects of the syntactic component are innate and that it is unique to our species. These issues will be discussed in turn in the two following sections.

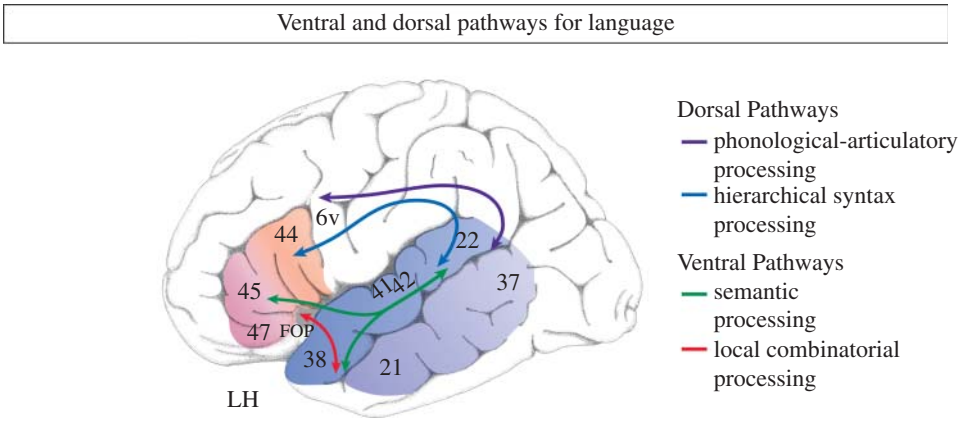


Figure 20.3 Ventral and dorsal pathways for language. Left hemispherical (LH) view of the human brain showing the two main dorsal pathways involved in syntactic processing and articulation and two main ventral pathways involved in local combinations and semantic processing in general. This model is based on data from both functional and anatomical neuroimaging. *Source*: Adapted from Goucha, Zaccarella, and Friederici (2017)

20.6 Ontogeny

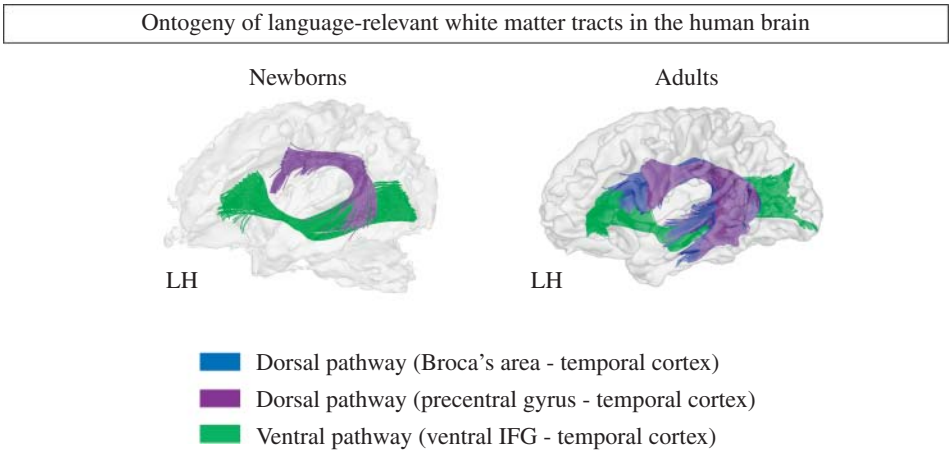
Empirical questions concerning the maturation of the linguistic network implementing syntax abilities in children include the degree of functional specialization of the language-relevant regions for syntactic processes, the shift between intrahemispheric to interhemispheric functional connections of the linguistic network, and the maturation of the ventral and dorsal tracts linking frontal and posterior temporal regions anatomically.

The ability to handle grammatical complexity in children is not fully mastered at least until the first seven years of life (Skeide and Friederici 2016). A first functional study testing syntactic complexity and semantics with plausible and implausible subject- and object-relative clauses in three age groups (3-4 years old; 6-7 years old, 9-10 years old) found that the adult dissociation between syntax and semantics on the neural level cannot be observed in children until the age of 7, as shown by syntax-semantics interactions in the left pSTG/mSTG, with involvement of the inferior-frontal regions below statistical threshold (Skeide, Brauer, and Friederici 2014). Only around the end of the tenth year of life children begin to approach first syntax-specific responses in the left IFG. BA 44 however does not seem to be fully specialized for complex syntax as in older children and adults yet (Nuñez et al. 2011), but it rather works coactively with more anterior regions in BA 45. Notably, another functional study could further show that increased neural activity in the left temporal regions – and to a lesser extent in BA 44 – can already be appreciated in five-year-old children with better syntactic proficiency in using case-marking cues during object- vs. subject-first sentences processing (Wu et al. 2016). A similar strong association between accuracy performance and functional activation in the temporo-frontal network was confirmed by a large correlational study across four age groups ranging from three years of age to young adulthood (Skeide, Brauer, and Friederici 2015). Collectively, these findings suggest that the neural resources for the development of syntactic knowledge initially primarily recruit the posterior superior temporal cortex, and only later they shift toward BA 44 as a function of age and proficiency.

When looking at changes in functional connectivity between pSTG and Broca's area, the coordination between these two regions as observed in the mature brain during speech and language processing only develops gradually from early infancy to adulthood (Dehaene-Lambertz, Dehaene, and Hertz-Pannier 2002; Perani et al. 2011). Whereas the adult brain exhibits a marked lateralization and intrahemispheric functional connectivity between Broca's area and pSTG, newborns show interhemispheric connectivity between these regions in the left hemisphere and their respective right-hemipsheric homologues, mainly between the superior temporal regions (Friederici, Brauer, and Lohmann 2011). The mature pattern of lateralization and increased functional connectivity between Broca's area and left pSTG can only be observed at around six years of age when using task-free measures such as resting-state fMRI (Xiao et al. 2016), thus indicating that maturation of the core language network ultimately leads to an increased specialization and functional segregation of the processing of semantic and syntactic information (Skeide, Brauer, and Friederici 2014).

Investigations into the anatomical development of brain functions, including language, move from the fact that while brain function relies on the transmission of electrical impulses from one brain region to another via white-matter pathways, the efficiency of information transmission is determined by the degree of myelination

of a particular fiber tract (Nave and Werner 2014; Wake, Lee, and Fields 2011). Different fiber tracts in the human brain exhibit distinct developmental trajectories as evidenced by their different degrees of myelination during maturation (Dubois et al. 2008; Lebel et al. 2012; 2008; Pujol et al. 2006). Crucially, the dorsal fiber tract connecting pSTG to BA 44 develops rather late during childhood and its degree of myelination is highly predictive for a child's capacity to process hierarchically complex sentences (Brauer, Anwander, and Friederici 2011; Skeide, Brauer, and Friederici 2016; Skeide and Friederici 2016). Conversely, the dorsal pathway targeting premotor cortex and the ventral pathway targeting BA 45 and more anterior portions of the inferior frontal gyrus area already well myelinated early on in life and thus highly functioning (Figure 20.4). These pathways support phonological learning during early infancy (Friederici, Mueller, and Oberecker 2011; Kuhl et al. 2006). As a matter of fact, analyses of the cortical microstructure measuring the volume of cell bodies in Broca's area indicate that leftward asymmetry in BA 44 is only visible around the age of 11 years, whereas leftward asymmetry of BA 45 is already present much earlier around 5 years of age (Amunts et al. 2003). Taken together, the maturation of the structural network including BA 44 in the IFG and the dorsal connection to the posterior temporal cortex appear to be crucial to the mastering of syntax processing in natural language.



adapted from Perani et al., 2011

Figure 20.4 Ontogeny of language-relevant white matter tracts in the human brain. Left hemispherical (LH) view of the newborn brain (left) and the adult brain (right) showing fiber tracking of diffusion tensor imaging data seeding in Broca's area and in the precentral gyrus/premotor cortex. Ventrally, the pathway connecting the ventral inferior frontal gyrus to the temporal cortex is present in both adults and newborns (extreme capsule, green). Dorsally, the adults show two pathways – one connecting the temporal cortex to Broca's area (arcuate fasciculus and superior longitudinal fasciculus, blue), and one connecting the temporal cortex to the premotor cortex (purple). In newborns, only the pathway to the premotor cortex can be detected whereas the connection to Broca's area matures late. *Source*: Adapted from Perani et al. (2011)

The initially weak structural integrity of the core language network raises the question as to how this relatively late maturation for complex syntax might nonetheless enable young children to begin mastering more basic merging combinations. Behavioral studies put forward the hypothesis that very young children might already be able to produce determiner-noun combinations ("the cat" or "a cat"), by freely combining determiners and nouns according to syntactic rules (Yang 2013), even in case of sensory-deprivation due to deafness and lack of systematized linguistic input (Goldin-Meadow and Yang 2017). Neural evidence further supports the idea that very young children might be already able to detect local phrase structure violations in the linguistic stream (Bernal et al. 2010; Brusini et al. 2016). During early childhood, linguistic processing might possibly depend on the pathways targeting the ventral connections to the IFG in order to allow for basic structure building (i.e. a single application of *Merge*). In contrast, the delayed processing of more complex recursive structures additionally require working memory resources in the more dorsal portions of Broca's area (Makuuchi et al. 2009), extending along the dorsal pathway to the posterior temporal cortex via the inferior parietal regions (Fengler, Meyer, and Friederici 2016; Meyer et al. 2012; Grossman et al. 2002). Following Chomsky's more recent ideas about language acquisition – i.e. the vast majority of the acquisition process may be dedicated to acquiring lexico-semantic knowledge specific to (externalization of) the target-language (Berwick and Chomsky 2016) – the working hypothesis is put forward that neural activity related to syntactic processing in the inferior frontal regions might be initially overshadowed by lexico-semantic processing in posterior temporal cortex, notwithstanding behavioral reliance on syntactic knowledge early on in life.

20.7 Phylogeny

From an evolutionary point of view, the neural mechanisms for syntactic structure building could have evolved in nonhuman species either via evolutionary convergence with an only distantly related species (e.g., songbirds), or by descent from a common primate ancestor (Bolhuis et al. 2014). Despite these principled reasons and continuous efforts to discover homologies of human language in nonhuman primates, there is so far no empirical evidence that any nonhuman species has evolved a system with the computational capacity exhibited by the human syntactic system (Beckers et al. 2012; Berwick et al. 2013; 2011; Bolhuis, Okanoya, and Scharff 2010; Bolhuis et al. 2014; Yang 2013). Given that the comparative method has been the standard approach to the study of language evolution a potentially demoralizing conclusion follows, namely that if language is specific to the human species then there actually may be "not much to compare" (Bolhuis et al. 2014).

The fact that we now have a solid neuroanatomical characterization of the core language network that subserves syntactic processing in humans invites cross-species comparisons to go beyond behavioral studies which have compared the performance of humans and nonhuman primates on comprehension and production tasks involving symbol combination and sequence processing (for a review see Friederici, in press). So far, all studies comparing the performance of humans and nonhuman primates on comprehension and production tasks involving symbol combination and sequence processing converge on the fact that nonhuman primates lack systematic combinatorics as they do not approach the ability of processing hierarchical sequences

that go beyond linear combinations (Fitch and Hauser 2004; Hauser, Chomsky, and Fitch 2002).

This conclusion holds up independent of the modality of language use and can therefore not be attributed mechanisms for vocal learning, as the use of sign language stimuli in studies with nonhuman primates has yielded similar results (Terrace et al. 1979; Yang 2013). Along these lines, a recent study analyzing the brain's white matter structure in hearing subjects and early deaf signers revealed a separation of the neural network for language and speech (Finkl et al. 2019). While no group difference was found for the language network, significant differences were found for the speech-related network, thereby providing further neural evidence for a separation between language and speech as postulated by Chomsky (Chomsky 1995, 2005; Friederici et al. 2017).

Converging on these conclusions, comparative functional neuroimaging studies have shown that the learning of linear sequences in nonhuman primates and humans differentially recruited frontal cortex in an interesting pattern: while macaques showed activation in the homologue to Broca's area – the ventral frontal opercular cortex – in response to simple forward-branching violations, neural activation in response to violations in humans was found in the frontal operculum in the ventral frontal cortex but not in Broca's area (Wilson et al. 2015). As monkeys appear to be able to learn non-hierarchical rule-based sequences, this has been suggested to be a possible phylogenetic precursor of phrase-structure processing in humans, and a possible cross-correspondence with language development in children (Friederici 2017).

The functional differences in the recruitment of frontal cortex during sequence processing and the apparent inability of nonhuman primates to process hierarchically structured phrases are also evidenced in differences with regard to brain structure and connectivity across species which parallel the immaturity of this network in humans in infancy. Cortical terminations of the arcuate fasciculus as the fiber pathway connecting Broca's area and pSTG in humans differ considerably between humans and nonhuman primates (Rilling et al. 2008; Perani et al. 2011). Moreover, cytoarchitectonic analyses reveal that, compared to humans, nonhuman primates like chimpanzees exhibits no leftward asymmetry, either in BA 45 or in BA 44 (Schenker et al. 2010). This regional asymmetry in humans compared to nonhuman primates is accompanied by a strong asymmetry of the arcuate fasciculus itself (Rilling et al. 2012; Rilling et al. 2008; Rilling 2014), thus pointing toward the view that dorsal fiber tract connecting BA 44 to the pSTG/STS might constitute a crucial neural precondition for linguistic humaniqueness – the capacity of handling hierarchical linguistic structures – to take place along evolution (Goucha, Zaccarella, and Friederici 2017).

20.8 Conclusion

In this chapter we discussed neuroanatomical evidence supporting humans' capacity to handle linguistic hierarchies. We started out from the view that human language results from a biologically determined grammar system generating linguistic sequences out of abstract hierarchical relations between words (Chomsky 1965, 1981, 1995). We first gave an overview of the early days of brain-syntax research and focused on those lesion studies assessing the cognitive nature of specific language impairments like agrammatism in Broca's aphasics. We stressed the importance of seminal works

using grammatical judgments to test language competence beyond prior performance distinctions between production and comprehension (Zurif, Caramazza, and Myerson 1972). Such studies paved the way to the emergence of modern neurobiology of language as the discipline linking together language and the brain, by using experimental methodologies to test theoretical predictions from linguistic theory at the neural level. In the central part of the chapter we discussed current objectives on the neuroanatomical reality of the syntactic component, isolating a fronto-temporal network in the left hemisphere that comprises the connection between BA 44 and posterior temporal cortex along the dorsal fiber track. We provided compelling neural evidence for a number of core aspects of human syntax put forward within the generative framework, including the existence of universal principles of grammar, neurally represented, which distinguish possible and impossible syntactic rules (Musso et al. 2003); the functional reality of hierarchical constituency (Pallier, Devauchelle, and Dehaene 2011); movement (Friederici et al. 2005); mechanisms of recursion (Friederici et al. 2006); the implementation of *Merge* (Zaccarella and Friederici 2015); and the time course dynamics driving the internal construction of hierarchical linguistic structure (Ding et al. 2016; Nelson et al. 2017). We then sketch out the development of the functional and structural network during childhood, giving an overview of maturation stages of the dorsal pathway for the mastering of syntax processing in natural language (Skeide and Friederici 2016). We concluded with the hypothesis that the dorsal fiber tract connecting BA 44 to the pSTG/STS might constitute a crucial neurological precondition for our capacity of handling hierarchical linguistic structures to emerge (Goucha, Zaccarella, and Friederici 2017).

We would like to end this chapter with a reflection on the legacy that Chomsky's ideas have had on the neuroscience of language. Such a legacy is according to us essentially twofold: the view of language as a biological system which is implemented in the human brain, and the idea that grammar and performance factors do not equate each other. These two aspects, we believe, are necessarily subsumed in any study approaching language in experimental settings. Such studies have in this sense offered empirical validation for the biological reality of core claims about the human capacity for language, as put forward in generative grammar and within the Minimalist framework. More importantly, they call for an increased collaboration between linguists and neuroscientists to bring the relation between linguistic phenomena and neural data to a deeper level of understanding (Friederici and Singer 2015; Poeppel 2012).

Conflicts of Interest

None of the authors has conflicts of interest to declare.

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Endnote

1 Overall, these studies attempt to implement plausible neuro-computational models involving an incremental parser that can track the on-line unfolding of linguistic strings, together with some linking hypothesis connecting parser states to neural signals (Brennan 2016). The specific parsing states depend on the relative strategy that a parser adopts – expansion (top-down), reduction (bottom-up), projection (left-corner) – according to a certain constituency grammar – e.g., context-free grammar, Minimalist grammar (Hale et al. 2015; Hale 2014; Li and Hale, 2019). The linking hypothesis would then correspond to some complexity metrics indexing each specific state of the parser – e.g., the node count for a specific word based on the different parsing strategy. In this respect, hierarchy-based models attempt to observe neural behavior correlating with phrase structure during actual performance, on the basis of detailed on-line parsing algorithms by which linguistic knowledge might be explicitly implemented (Bhattasali et al. 2019; Nelson et al. 2017). While such approaches remain necessarily agnostic with respect to structure-building operations per se, as they only test general parsing assumptions, improved performance-oriented approaches using more transparent translational hypothesis to test structure-building operations are now emerging (Chesi 2012; 2014; Chesi and Canal 2019; Fong 2014).

References

Amunts, Katrin, and Karl Zilles. 2012. Architecture and organizational principles of Broca's Region. *Trends in Cognitive Sciences* 16 (8): 418–426. DOI:10.1016/j.tics.2012.06.005.

Beckers, Gabriael J, Johan J Bolhuis, Kazuo Okanoya, and Richard C Berwick. 2012. Birdsong neurolinguistics: Songbird context-free grammar claim is premature. *Neuroreport* 23 (3): 139–145. DOI:10.1097/WNR.0b013e32834f1765.

Bernal, S, G Dehaene-Lambertz, S Millotte, and A Christophe. 2010. Two-year-olds compute syntactic structure on-line. *Developmental Science* 13 (1): 69–76. DOI:10.1111/j.1467-7687.2009.00865.x.

Berwick, Robert C., and Noam Chomsky. 2016. *Why Only Us: Language and Evolution*. Cambridge: MIT Press.

Berwick, Robert C, Angela D Friederici, Noam Chomsky, and Johan J Bolhuis. 2013. Evolution, brain, and the nature of language. *Trends in Cognitive Sciences* 17 (2): 89–98. DOI:10.1016/j.tics.2012.12.002.

Berwick, Robert C, Kazuo Okanoya, Gabriael J Beckers, and Johan J Bolhuis. 2011. Songs to syntax: The linguistics of birdsong. *Trends Cogn Sci* 15 (3): 113–21. DOI:10.1016/j.tics.2011.01.002.

Bhattasali, Shohini, Murielle Fabre, Wen Ming Luh, Hazem Al Saied, Mathieu Constant, Christophe Pallier, Jonathan R. Brennan, R. Nathan Spreng, and John Hale. 2019. Localising Memory Retrieval and Syntactic Composition: An FMRI Study of Naturalistic Language Comprehension. *Language, Cognition and Neuroscience* 34 (4): 491–510. DOI:10.1080/23273798.2018.1518533.

Bolhuis, Johan J, Kazuo Okanoya, and Constance Scharff. 2010. Twitter evolution: Converging mechanisms in birdsong and human speech. *Nature Reviews. Neuroscience* 11 (11): 747–59. DOI:10.1038/nrn2931.

Bolhuis, Johan J, Ian Tattersall, Noam Chomsky, and Robert C Berwick. 2014. How could language have evolved?" *PLoS Biology* 12 (8): e1001934. DOI:10.1371/journal.pbio.1001934.

Brennan, Jonathan. 2016. Naturalistic sentence comprehension in the brain. *Language and Linguistics Compass* 10 (7): 299–313. DOI:10.1111/lnc3.12198.

Brennan, Jonathan R., and John T. Hale. 2019. Hierarchical structure guides rapid linguistic predictions during naturalistic listening. *PLoS ONE* 14 (1): e0207741. DOI:10.1371/journal.pone.0207741.

Brennan, Jonathan R, Edward P Stabler, Sarah E Van Wagenen, Wen-Ming Luh, and John T Hale. 2016. Abstract linguistic structure correlates with temporal activity during naturalistic comprehension. *Brain and Language* 157–158: 81–94. DOI:10.1016/j.bandl.2016.04.008.

Broca, Paul. 1861. Remarques Sur Le Siége de La Faculté Du Langage Articulé, Suivies d'une Observation d'aphémie (Perte de La Parole). *Bulletins de La Société Anatomique de Paris* 6: 330–57.

Brusini, Perrine, Ghislaine Dehaene-Lambertz, Michel Dutat, François Goffinet, and Anne Christophe. 2016. ERP evidence for on-line syntactic computations in 2-year-olds. *Developmental Cognitive Neuroscience* 19: 164–73. DOI:10.1016/j.dcn.2016.02.009.

Caramazza, Alfonso, and Edgar B Zurif. 1976. Dissociation of algorithmic and heuristic processes in language comprehension: Evidence from aphasia. *Brain and Language* 3 (4): 572–82.

Catani, Marco, and Michel Thiebaut de Schotten. 2008. A diffusion tensor imaging tractography atlas for virtual in vivo dissections. *Cortex* 44 (8): 1105–32. DOI:10.1016/j.cortex.2008.05.004.

Chesi, Cristiano. 2012. *Competence and Computation: Towards a Processing Friendly Minimalist Grammar*. Padova: Unipress.

———. 2014. On directionality of phrase structure building. *Journal of Psycholinguistic Research* 44 (1): 65–89. DOI:10.1007/s10936-014-9330-6.

Chesi, Cristiano, and Paolo Canal. 2019. Person features and lexical restrictions in Italian clefts. *Frontiers in Psychology* 10 (September). DOI:10.3389/fpsyg.2019.02105.

Chomsky, Noam. 1965. *Aspects of the Thory of Syntax*. Cambridge: MIT Press.

———. 1981. *Lectures on Government and Binding: The Pisa Lectures*. Dordrecht: Foris Publications.

———. 1995. *The Minimalist Program. Current Studies in Linguistics*. Cambridge: MIT Press.

———. 2005. Three factors in language design. *Linguistic Inquiry* 36 (1): 1–22. DOI:10.1162/0024389052993655.

Dax, Gustave. 1863. M. Dax Soumet Au Jugement de l'Académie Un Mémoire Intitulé: 'Observations Tendant à Prouver La Coïncidence Constante Des Dérangements de La Parole Avec Une Lésion de l'hémisphère Gauche Du Cerveau'. *Compt.Rend.Hebdom.Séan.l'Acad Scien* 56: 536.

Dax, Marx. 1865. Lésions de La Moitié Gauche de l'encéphale Coïncident Avec l'oubli Des Signes de La Pensée (Lu à Montpellier En 1836). *Bulletin Hebdomadaire de Médecine et de Chirurgie, 2me Série* 2: 259–262.

Dehaene-Lambertz, Ghislaine, Stanislas Dehaene, and Lucie Hertz-Pannier. 2002. Functional neuroimaging of speech perception in infants. *Science* 298 (5600): 2013–15. DOI:10.1126/science.1077066.

Ding, Nai, Lucia Melloni, Hang Zhang, Xing Tian, and David Poeppel. 2016. Cortical tracking of hierarchical linguistic structures in connected speech. *Nature Neuroscience* 19 (1): 158–164. DOI:10.1038/nn.4186.

Dronkers, Nina F., Odile Plaisant, Marie T. Iba-Zizen, and Emmanuel, A. Cabanis. 2007. Paul Broca's historic cases: High resolution MR imaging of the brains of Leborgne and Lelong. *Brain* 130 (5): 1432–1441. DOI:10.1093/brain/awm042.

Dubois, Jessica, Ghislaine Dehaene-Lambertz, Muriel Perrin, Jean François Mangin, Yann Cointepas, Edouard Duchesnay, Denis Le Bihan, and Lucie Hertz-Pannier. 2008. Asynchrony of the early maturation of white matter bundles in healthy infants: Quantitative landmarks revealed noninvasively by diffusion tensor imaging. *Human Brain Mapping* 29 (1): 14–27. DOI:10.1002/hbm.20363.

Everaert, Martin B, Marinus A Huybregts, Noam Chomsky, Richard C Berwick, and Johan J Bolhuis. 2015. Structures, not strings: Linguistics as part of the cognitive sciences. *Trends Cogn Sci* 19 (12): 729–743. DOI:10.1016/j.tics.2015.09.008.

Fengler, Anja, Lars Meyer, and Angela D Friederici. 2016. How the brain attunes to sentence processing: Relating behavior, structure, and function. *NeuroImage* 129: 268–278. DOI:10.1016/j.neuroimage.2016.01.012.

Finkl, Theresa, Anja Hahne, Angela D Friederici, Johannes Gerber, Dirk Mürbe, and Alfred Anwander. 2019. Language without speech: Segregating distinct circuits in the human brain. *Cerebral Cortex*. DOI:10.1093/cercor/bhz128.

Fitch, W Tecumseh, and Marc D Hauser. 2004. Computational constraints on syntactic processing in a nonhuman primate. *Science* 303 (5656): 377–80. DOI:10.1126/science.1089401.

Fong, Sandiway. 2014. Unification and efficient computation in the Minimalist Program. In *Language and Recursion*, edited by F. Lowenthal and L. Lefebvre, 129–38. New York, NY: Springer Science+Business Media.

Frank, Stefan L., Rens Bod, and Morten H. Christiansen. 2012. How hierarchical is language use?" *Proceedings of the Royal Society B: Biological Sciences* 279 (1747): 4522–31. DOI:10.1098/rspb.2012.1741.

Frank, Stefan L., and Morten H. Christiansen. 2018. Hierarchical and sequential processing of language. *Language, Cognition and Neuroscience* 33 (9): 1213–18. DOI:10.1080/23273798.2018.1424347.

Frank, Stefan L., and Jinbiao Yang. 2018. Lexical representation explains cortical entrainment during speech comprehension. *PLoS ONE* 13 (5): e0197304. DOI:10.1371/journal.pone.0197304.

Friederici, Angela D. 2019. *Hierarchy processing in human neurobiology: How specific is it?*" Philosophical *Transactions B*. DOI:10.1098/rstb.2018.0391

– – – . 1981. Production and comprehension of prepositions in Aphasia. *Neuropsychologia* 19 (2): 191–99. DOI:10.1016/0028-3932(81)90104-4.

– – – . 2011. The brain basis of language processing: From structure to function. *Physiological Reviews* 91 (4): 1357–92. DOI:10.1152/physrev.00006.2011.

– – – . 2017. Evolution of the neural language network. *Psychonomic Bulletin & Review* 24 (1): 41–47. DOI:10.3758/s13423-016-1090-x.

Friederici, Angela D, Joerg Bahlmann, Stefan Heim, Richarda I Schubotz, and Alfred Anwander. 2006. The brain differentiates human and non-human grammars: functional localization and structural connectivity. *Proceedings of the National Academy of Sciences of the United States of America* 103 (7): 2458–63. DOI:10.1073/pnas.0509389103.

Friederici, Angela D, Jens Brauer, and Gabriele Lohmann. 2011a. Maturation of the Language Network: From Inter- to intrahemispheric connectivities. *PLoS ONE* 6 (6): e20726. DOI:10.1371/journal.pone.0020726.

Friederici, Angela D, Noam Chomsky, Robert C. Berwick, Andrea Moro, and Johan J. Bolhuis. 2017. Language, mind and brain. *Nature Human Behaviour* 1 (10): 713–22. DOI:10.1038/s41562-017-0184-4.

Friederici, Angela D, Jutta L Mueller, and Regina Oberecker. 2011b. Precursors to natural grammar learning: Preliminary evidence from 4-month-old infants. *PLoS ONE* 6 (3): e17920. DOI:10.1371/journal.pone.0017920.

Friederici, Angela D, Paul W Schönle, and Merrill F Garrett. 1982. Syntactically and Semantically based computations: Processing of prepositions in agrammatism. *Cortex* 18 (4): 525–34. DOI:10.1016/S0010-9452(82)80051-8.

Friederici, Angela D, and Wolf Singer. 2015. Grounding language processing on basic neurophysiological principles. *Trends in Cognitive Sciences* 19 (6): 329–38. DOI:10.1016/j.tics.2015.03.012.

Friederici, A. D., Fiebach, C. J., Schlesewsky, M., Bornkessel, I. D., & von Cramon, D. Y. (2005). Processing Linguistic Complexity and Grammaticality in the Left Frontal Cortex. *Cerebral Cortex*, 16 (12): 1709–1717. DOI:10.1093/cercor/bhj106.

Friederici, Angela D.; Makuuchi, Michiru; Bahlmann, Jörg (2009). The role of the posterior superior temporal cortex in sentence comprehension. *NeuroReport* 20 (6): 563–568. DOI:10.1097/wnr.0b013e3283297dee.

Friston, Karl .J., Lee, Harrison, and William, Penny. 2003. Dynamic causal modelling. *NeuroImage* 19 (4): 1273–1302. DOI:10.1016/S1053-8119(03)00202-7.

Geschwind, Norman. 1970. The organization of language and the brain. *Science* 170 (3961): 940–44. DOI:10.1126/science.170.3961.940.

Goldin-Meadow, Susan, and Charles Yang. 2017. Statistical evidence that a child can create a combinatorial linguistic system without external linguistic input: Implications for language evolution. *Neuroscience & Biobehavioral Reviews* 81 (Pt B): 150–57. DOI:10.1016/j.neubiorev.2016.12.016.

Goodglass, Harold, Jean B Gleason, and Mary R Hyde. 1970. Some dimensions of auditory language comprehension in Aphasia. *Journal of Speech and Hearing Research* 13 (3): 595–606. DOI:10.1044/jshr.1303.595.

Goucha, Tomás, and Angela D Friederici. 2015. The language skeleton after dissecting meaning: A functional segregation within Broca's area. *Neuroimage* 114: 294–302. DOI:10.1016/j.neuroimage.2015.04.011.

Goucha, Tomás, Emiliano Zaccarella, and Angela. D. Friederici. 2017. A revival of H*omo Loquens* as a builder of labeled structures: Neurocognitive considerations. *Neuroscience and Biobehavioral Reviews* 81 (Pt B): 213–24. DOI:10.1016/j.neubiorev.2017.01.036.

Green, Eugene. 1970. On the contribution of studies in Aphasia to psycholinguistics. *Cortex* 6 (2): 216–35. DOI:10.1016/S0010-9452(70)80029-6.

Grodzinsky, Y. 2000. The neurology of syntax: Language use without Broca's area. *The Behavioral and Brain Sciences* 23 (1): 1–21; discussion 21-71. http://www.ncbi.nlm.nih.gov/pubmed/11303337.

Grossman, Murray, Ayanna Cooke, Chris DeVita, David Alsop, John Detre, Willis Chen, and James Gee. 2002. Age-related changes in working memory during sentence comprehension: An FMRI Study. *NeuroImage* 15 (2): 302–17. DOI:10.1006/nimg.2001.0971.

Hagoort, Peter. 2013. MUC (Memory, unification, control) and beyond. *Front Psychol* 4: 416. DOI:10.3389/fpsyg.2013.00416.

– – – . 2014. Nodes and networks in the neural architecture for language: Broca's region and beyond. *Current Opinion in Neurobiology* 28: 136–41. DOI:10.1016/j.conb.2014.07.013.

Hagoort, Peter, and Peter Indefrey. 2014. The neurobiology of language beyond single words. *Annual Review of Neuroscience* 37: 347–62. DOI:10.1146/annurev-neuro-071013-013847.

Hale, John T. 2014. *Automaton Theories of Human Sentence Comprehension*. CSLI Studies in Computational Linguistics.

Hale, John T, David Lutz, Wen-Ming Luh, and Jonathan Brennan. 2015. Modeling FMRI time courses with linguistic structure at various grain sizes. *In 89–97*. Association for Computational Linguistics (ACL). DOI:10.3115/v1/w15-1110.

Harris, Zelig S. 1946. From morpheme to utterance. *Language* 22: 161–83.

Hauser, Marc D, Noam Chomsky, and W Tecumseh Fitch. 2002. The Faculty of Language: What is it, who has it, and how did it evolve?" *Science* 298 (5598): 1569–79. DOI:10.1126/science.298.5598.1569.

Holmberg, Anders. 2000. Am I Unscientific? A reply To Lappin, Levine, *and Johnson. Natural Language and Linguistic Theory* 18 (4): 837–42. DOI:10.1023/A:1006425604798.

Kuhl, Patricia K, Erica Stevens, Akiko Hayashi, Toshisada Deguchi, Shigeru Kiritani, and Paul Iverson. 2006. Infants Show a Facilitation Effect for Native Language Phonetic Perception between 6 and 12 Months. *Developmental Science* 9 (2): 13–21. DOI:10.1111/j.1467-7687.2006.00468.x.

Lappin, Shalom, Robert D. Levine, and David E. Johnson. 2000. The Revolution Confused: A Response to Our Critics. *Natural Language & Linguistic Theory* 18 (4): 873–90. DOI:10.2307/4047986.

– – –. 2000. The Structure of Unscientific Revolutions. *Natural Language & Linguistic Theory* 18: 665–71. DOI:10.2307/4047942.

Lappin, Shalom, Robert Levine, and David Johnson. 2001. The revolution maximally confused. *Natural Language and Linguistic Theory* 19 (4): 901–19. DOI:10.1023/A:1013397516214.

Lebel, Catherine, Myrlene Gee, Richard Camicioli, Marguerite Wieler, Wayne Martin, and Christian Beaulieu. 2012. Diffusion tensor imaging of white matter tract evolution over the lifespan. *NeuroImage* 60 (1): 340–52. DOI:10.1016/j.neuroimage.2011.11.094.

Lebel, Catherine, Lindsay Walker, Alexander Leemans, Linda Phillips, and Chr Beaulieu. 2008. Microstructural maturation of the human brain from childhood to adulthood. *NeuroImage* 40 (3): 1044–55. DOI:10.1016/j.neuroimage.2007.12.053.

Lenneberg, Eric H. 1969. On explaining language. *Science* 164 (3880): 635–43. DOI:10.1126/science.164.3880.635.

Li, Jixing, and John Hale. 2019. Grammatical predictors for FMRI timecourses. In *Minimalist Parsing*. Oxford University Press. pp. 159–163. https://global.oup.com/academic/product/minimalist-parsing-9780198795087?cc=us?=en&#

Lichtheim, Ludwig. 1884. On Aphasia. *Brain* 7 (4): 433–84.

Lohmann, Gabriele, Stefanie Hoehl, Jens Brauer, Claudia Danielmeier, Ina Bornkessel-Schlesewsky, Joerg Bahlmann, Robert Turner, and Angela Friederici. 2010. Setting the frame: The human brain activates a basic low-frequency network for language processing. *Cerebral Cortex* 20 (6): 1286–92. DOI:10.1093/cercor/bhp190.

Makuuchi, M, J Bahlmann, A Anwander, and A D Friederici. 2009. Segregating the core computational faculty of human language from working memory. *Proceedings of the National Academy of Sciences of the United States of America* 106 (20): 8362–67. DOI:10.1073/pnas.0810928106.

Makuuchi, Michiru, and Angela D Friederici. 2013. Hierarchical functional connectivity between the core language system and the working memory system. *Cortex; a Journal Devoted to the Study of the Nervous System and Behavior* 49 (9): 2416–23. DOI:10.1016/j.cortex.2013.01.007.

Matchin, William, and Gregory Hickok. 2019. The cortical organization of syntax. *Cerebral Cortex, October.* DOI:10.1093/cercor/bhz180.

McDonald, Scott A., and Richard C. Shillcock. 2003. Eye movements reveal the on-line computation of lexical probabilities during reading. *Psychological Science* 14 (6): 648–52. DOI:10.1046/j.0956-7976.2003.psci_1480.x.

Meyer, L, J Obleser, A Anwander, and A D Friederici. 2012. Linking Ordering in Broca's area to Storage in Left Temporo-Parietal Regions: The case of sentence processing. *Neuroimage* 62 (3): 1987–98. DOI:10.1016/j.neuroimage.2012.05.052.

Milne, Alice E, Jutta L Mueller, Claudia Männel, Adam Attaheri, Angela D Friederici, and Christopher I Petkov. 2016. Evolutionary origins of non-adjacent sequence processing in primate brain potentials. *Scientific Reports* 6: 36259. DOI:10.1038/srep36259.

Milne, Alice E, Christopher I Petkov, and Benjamin Wilson. 2018. Auditory and visual sequence learning in humans and monkeys using an artificial grammar learning paradigm. *Neuroscience* 389: 104–17. DOI:10.1016/j.neuroscience.2017.06.059.

Musso, Mariacristina, Andrea Moro, Volkmar Glauche, Michel Rijntjes, Jürgen Reichenbach, Christian Buchel, and Cornelius Weiller. 2003. Broca's area and the language instinct. *Nature Neuroscience* 6 (7): 774–81. DOI:10.1038/nn1077.

Nave, Klaus-Armin, and Hauke B. Werner. 2014. Myelination of the nervous system: Mechanisms and functions. *Annual Review of Cell and Developmental Biology* 30 (1): 503–33. DOI:10.1146/annurev-cellbio-100913-013101.

Nelson, Matthew J, Imen El Karoui, Kristof Giber, Xiaofang Yang, Laurent Cohen, Hilda Koopman, Sydney S Cash, et al. 2017. Neurophysiological dynamics of phrase-structure building during sentence processing. *Proceedings of the National Academy of Sciences of the United States of America* 114 (18): E3669–78. DOI:10.1073/pnas.1701590114.

Nida, Eugene A. 1948. The analysis of immediate costituent. *Language* 24: 168–77.

Nunes, Jairo. 2011. The copy theory. *In The Oxford Handbook of Linguistic Minimalism. Oxford University Press.* DOI:10.1093/oxfordhb/9780199549368.013.0007.

Nuñez, S. Christopher, Mirella Dapretto, Tami Katzir, Ariel Starr, Jennifer Bramen, Eric Kan, Susan Bookheimer, and Elizabeth R. Sowell. 2011. FMRI of Syntactic processing in typically developing children: Structural correlates in the inferior frontal gyrus. *Developmental Cognitive Neuroscience* 1 (3): 313–23. DOI:10.1016/j.dcn.2011.02.004.

Ouden Dirk-Bart den, Dorothee Saur, Wolfgang Mader, Björn Schelter, Sladjana Lukic, Eisha Wali, Jens Timmer, and Cynthia K Thompson. 2012. Network modulation during complex syntactic processing. *Neuroimage* 59 (1): 815–23. DOI:10.1016/j.neuroimage.2011.07.057.

Pallier, Christophe, Anne D Devauchelle, and Stanislas Dehaene. 2011. Cortical representation of the constituent structure of sentences. *Proceedings of the National Academy of Sciences of the United States of America* 108 (6): 2522–27. DOI:10.1073/pnas.1018711108.

Perani, Daniela, Maria C Saccuman, Paola Scifo, Alfred Anwander, Danilo Spada, Cristina Baldoli, Antonella Poloniato, Gabriele Lohmann, and Angela D Friederici. 2011. Neural language networks at birth. *Proceedings of the National Academy of Sciences of the United States of America* 108 (38): 16056–61. DOI:10.1073/pnas.1102991108.

Piattelli-Palmarini, Massimo. 2000. The metric of open-mindedness. *Natural Language and Linguistic Theory* 18 (4): 859–62. DOI:10.1023/A:1006460406615.

Pike, Kenneth. L. 1943. Taxemes and immediate constituents. *Language* 19 (65–82).

Poeppel, D. 2012. The maps problem and the mapping problem: Two challenges for a Cognitive neuroscience of speech and language. *Cognitive Neuropsychology* 29 (1–2): 34–55. DOI:10.1080/02643294.2012.710600.

Pujol, Jesús P, Carles Soriano-Mas, Héctor Ortiz, Núria Sebastián-Gallés, Josep M Losilla, and Joan Deus. 2006. Myelination of language-related areas in the developing brain. *Neurology* 66 (3): 339–43. DOI:10.1212/01.wnl.0000201049.66073.8d.

Raymer, Anastasia M., and Leslie J.Gonzalez Rothi. 2015. *The Oxford Handbook of Aphasia and Language Disorders*. Oxford University Press. DOI:10.1093/oxfordhb/9780199772391.001.0001.

Reinhart, Tanya. 1976. *The Syntactic Domain of Anaphora*. MIT.

Reuland, Eric. 2000. Revolution, discovery, and an elementary principle of logic. *Natural Language and Linguistic Theory* 18 (4): 843–48. DOI:10.1023/A:1006404305706.

Rilling, James, Matthew Glasser, Saad Jbabdi, Jesper Andersson, and Todd Preuss. 2012. Continuity, divergence, and the evolution of brain language pathways. *Frontiers in Evolutionary Neuroscience* 3: 3–11. DOI:10.3389/fnevo.2011.00011.

Rilling, James K. 2014. Comparative primate neurobiology and the evolution of brain language systems. *Current Opinion in Neurobiology* 28 (October): 10–14. DOI:10.1016/j.conb.2014.04.002.

Rilling, James K, Matthew F Glasser, Todd M Preuss, Xiangyang Ma, Tiejun Zhao, Xiaoping Hu, and Timothy E Behrens. 2008. The evolution of the Arcuate Fasciculus revealed with comparative DTI. *Nature Neuroscience* 11 (4): 426–28. DOI:10.1038/nn2072.

Roberts, Ian. 2000. Caricaturing dissent. *Natural Language and Linguistic Theory* 18 (4): 849–57. DOI:10.1023/A:1006408422545.

Sanides, Friedrich. 1962. *Die Architektonik Des Menschlichen Stirnhirns*. Berlin: Springer.

Saur, Dorothee, Björn W Kreher, Susanne Schnell, Dorothee Kummerer, Philipp Kellmeyer, Magnus S Vry, Roza Umarova, et al. 2008. Ventral and dorsal pathways for language. *Proceedings of the National Academy of Sciences of the United States of America* 105 (46): 18035–40. DOI:10.1073/pnas.0805234105.

Schell, Marianne, Emiliano Zaccarella, and Angela D Friederici. 2017. Differential cortical contribution of syntax and semantics: An FMRI Study on two-word phrasal processing. *Cortex* 96: 105–20. DOI:10.1016/j.cortex.2017.09.002.

Schenker, Natalie M, William D Hopkins, Muhammad A Spocter, Amy R Garrison, Cheryl D Stimpson, Joseph M Erwin, Patrick R Hof, and Chet C Sherwood. 2010. Broca's area homologue in chimpanzees (Pan Troglodytes): Probabilistic mapping, asymmetry, and comparison to humans. *Cerebral Cortex* 20 (3): 730–42. DOI:10.1093/cercor/bhp138.

Skeide, Michael A., Jens Brauer, and Angela D. Friederici. 2014. Syntax gradually segregates from semantics in the developing brain. *NeuroImage* 100: 106–11. DOI:10.1016/J.NEUROIMAGE.2014.05.080.

Skeide, Michael A., and Angela D. Friederici. 2016. The ontogeny of the cortical language network. *Nature Reviews Neuroscience* 17 (5): 323–32. DOI:10.1038/nrn.2016.23.

Skeide, Michael A, Jens Brauer, and Angela D Friederici. 2015. Brain functional and structural predictors of language performance. *Cerebral Cortex* 26 (5): 2127–39. DOI:10.1093/cercor/bhv042.

Terrace, Herb S, Laura A Petitto, Richard J Sanders, and Thomas G Bever. 1979. Can an ape create a sentence? *Science* 206 (4421): 891–902. DOI:10.1126/science.504995.

Tettamanti, Marco, Hatem Alkadhi, Andrea Moro, Daniela Perani, Spyros Kollias, and Dorothea Weniger. 2002. Neural correlates for the acquisition of natural language syntax. *NeuroImage* 17 (2): 700–709. DOI:10.1006/nimg.2002.1201.

Tremblay, Pascale, and Anthony Steven Dick. 2016. Broca and Wernicke are dead, or moving past the classic model of language neurobiology. *Brain and Language* 162: 60–71. DOI:10.1016/j.bandl.2016.08.004.

Uriagereka, Juan. 2000. On the emptiness of 'design' polemics. *Natural Language and Linguistic Theory* 18 (4): 863–71. DOI:10.1023/A:1006412507524.

Wake, Hiroaki, Philip R. Lee, and R. Douglas Fields. 2011. Control of local protein synthesis and initial events in myelination by action potentials. *Science* 333 (6049): 1647–51. DOI:10.1126/science.1206998.

Weigl, Egon, and Manfred Bierwisch. 1970. 3. Neuropsychology and linguistics: Topics of common research. In *Neuropsychology and Neurolinguistics*, 6:1–18. Springer. DOI:10.1515/9783110809107-007.

Wells, Rulon S. 1947. Immediate constituents. *Language* 23: 81–117.

Wernicke, Carl. 1874. *Der Aphasische Symptomencomplex*. Berlin: Springer-Verlag.

Wilson, Benjamin, Heather Slater, Yukiko Kikuchi, Alice E. Milne, William D. Marslen-Wilson, Kenny Smith, and Christopher I. Petkov. 2013. Auditory artificial grammar learning in macaque and marmoset monkeys. *Journal of Neuroscience* 33 (48): 18825–35. DOI:10.1523/JNEUROSCI.2414-13.2013.

Wilson, Bnejamin, Yukiko Kikuchi, Li Sun, David Hunter, Frederic Dick, Kenny Smith, Alexander Thiele, Timothy D Griffiths, William D Marslen-Wilson, and Christopher I Petkov. 2015. Auditory sequence processing reveals evolutionarily conserved regions of frontal cortex in macaques and humans. *Nature Communications* 6: 8901. DOI:10.1038/ncomms9901.

Wilson, Stephen M. 2017. Lesion-symptom mapping in the study of spoken language understanding. *Language, Cognition and Neuroscience* 32 (7): 891–99. DOI:10.1080/23273798.2016.1248984.

Wu, Chiao Yi, Kodjo Vissiennon, Angela D. Friederici, and Jens Brauer. 2016. Preschoolers' brains rely on semantic cues prior to the mastery of syntax during sentence comprehension. *NeuroImage* 126: 256–66. DOI:10.1016/j.neuroimage.2015.10.036.

Wu, Chiao Yi, Emiliano Zaccarella, and Angela D. Friederici. 2019. Universal neural basis of structure building evidenced by network modulations emerging from Broca's area: The case of Chinese. *Human Brain Mapping* 40 (6): 1705–17. DOI:10.1002/hbm.24482.

Yang, Charles. 2013. Ontogeny and phylogeny of language. *Proceedings of the National Academy of Sciences of the United States of America* 110 (16): 6324–27. DOI:10.1073/pnas.1216803110.

Zaccarella, E, and Angela D Friederici. 2015. Merge in the human brain: A sub-region based functional investigation in the left pars opercularis. *Frontiers in Psychology* 6: 1818. DOI:10.3389/fpsyg.2015.01818.

Zaccarella, E, Lars Meyer, Michiru Makuuchi, and Angela D Friederici. 2017. Building by Syntax: The neural basis of minimal linguistic structures. *Cerebral Cortex* 27 (1): 411–21. DOI:10.1093/cercor/bhv234.

Zaccarella, E, Marianne Schell, and Angela D Friederici. 2017. Reviewing the functional basis of the syntactic merge mechanism for language: A coordinate-based activation likelihood estimation meta-analysis. *Neuroscience and Biobehavioral Reviews* 80: 646–56. DOI:10.1016/j.neubiorev.2017.06.011.

– – – . 2017. Reviewing the functional basis of the syntactic merge mechanism for language: A coordinate-based activation likelihood estimation meta-analysis. *Neuroscience and Biobehavioral Reviews* 80: 646–56. DOI:10.1016/j.neubiorev.2017.06.011.

Zilles, Karl, and Katrin Amunts. 2018. Cytoarchitectonic and receptorarchitectonic organization in Broca's Region and surrounding cortex. *Current Opinion in Behavioral Sciences* 21: 93–105. DOI:10.1016/j.cobeha.2018.02.011.

Zubicaray, Greig I. de, and Niels O. Schille, eds. 2019. *The Oxford Handbook of Neurolinguistics*. Oxford: Oxford University Press. DOI:10.1093/oxfordhb/9780190672027.001.0001.

Zurif, Edgar B, Alfonso Caramazza, and Roger Myerson. 1972. Grammatical judgments of agrammatic aphasics. *Neuropsychologia* 10 (4): 405–17. DOI:10.1016/0028-3932(72)90003-6.

21

Universal Grammar and Language Acquisition

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21.1 Introduction

There is a prerequisite to empirical research on the acquisition of language. The prerequisite is an understanding of the linguistic principles that are operative in adult languages. This is a necessary precondition to informed empirical assessments about those aspects of language that children plausibly learn from experience versus those that are more likely to be innately specified. In assessing children's knowledge of a linguistic principle, there are several hallmarks of innateness (Crain 1991). One hallmark is early emergence. If child language learners adhere to a linguistic principle early in the course of language development, this lends credence to innateness by compressing the time that children have to accumulate relevant facts through experience. If, in addition, there is little or no decisive evidence for the principle in children's linguistic input, then this further reinforces the plausibility of innateness.

Of course, no one denies that input matters. But it is widely acknowledged that children's input is impoverished in several important respects (see Crain, Giblin, and Thornton, Chaper 29, this volume). One way the input is impoverished is the absence of "negative" evidence. There are two kinds of negative evidence. One kind is information that certain strings of words are unacceptable in the local language (Gold 1967). Another kind of negative evidence is information that speakers of the local language cannot assign certain meanings to strings of words that are acceptable. As far as we know, child language learners lack negative evidence of both kinds (e.g. Bowerman 1988, p. 94; Brown and Hanlon 1970; Marcus 1993; Pinker 1984).

The absence of negative evidence is potentially problematic for language learnability. One way child language learners may avoid the problem is to come pre-equipped with knowledge of linguistic principles that dictate the forms and meanings that are and are not acceptable in adult languages. This is where Noam Chomsky's proposals about Universal Grammar (UG) enter into the picture. UG is a theory about the innate linguistic knowledge that child language learners bring to the task of language acquisition. UG is not a list of properties that are common to all human languages, as is commonly

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supposed (cf. Evans and Levinson 2009; Dabrowska 2015; Tomasello 2000, 2003). It would be surprising, however, if principles of UG were not recurring themes witnessed across languages. Principles of UG are designed to explain "deep-seated regularities" (Chomsky 1965, p. 6). These regularities are deep-seated in the sense that they unify what often appear to be unrelated linguistic facts. By amalgamating disparate-looking phenomena, linguistic principles reduce the number of unrelated facts that child language learners must have accumulated in order to converge on a grammar that is equivalent to that of adults. Although the deep-seated principles of human languages take on many guises within and across languages, they assume a major role in language acquisition.

The deep-seated regularities of human languages should not be confused with the statistical (distributional) regularities in the input to children. There is much confusion on this point, because researchers from different theoretical perspectives invoke different notions of "regularities," as well as different notions of what are considered to be "core" phenomena. According to researchers who adopt the usage-based approach to language acquisition, core phenomena are "the more general, regular, frequent cases" (Goldberg 2003, p. 222); "the more regular and canonical aspects of a language" (Tomasello 2003, pp. 104–105).

The finding that child language learners amalgamate phenomena that do not appear related distinguishes the formalist approach and the usage-based approach. The usage-based approach contends that child language learners form generalizations based solely on the input, without assistance from abstract linguistic principles. This approach contends that, in forming generalizations, child language learners draw upon a small set of general-purpose cognitive processes, including analogy and the distributional analysis of the input (Ambridge and Lieven 2011, Ibbotson 2013). On the usage-based approach, strings of words that bear little resemblance to one another are acquired piecemeal (Tomasello 2000).

On the formalist approach, UG equips child language learners with principles that tie together strings of words that bear little resemblance on the surface. This chapter examines the findings of experimental research on children's knowledge of one principle of UG, called Principle C. The next section presents the defining properties of Principle C. Following that, we review empirical evidence showing that children apply Principle C to a range of disparate-looking phenomena. The phenomena are illustrated in examples (1) to (5).

(1) a) **He** said <u>Marcel</u> was the winner.
b) <u>Marcel</u> said <u>he</u> was the winner.

(2) a) It was <u>Marcel</u> who **he** said was the winner.
b) It was <u>Marcel</u> who said <u>he</u> was the winner.

(3) a) In <u>every pirate</u>'s barrel, **he** put a gun.
b) <u>Every pirate</u> put a gun in <u>his</u> barrel.

(4) a) I know <u>who</u> **he** said has the best smile.
b) I know <u>who</u> said <u>he</u> has the best smile.

(5) a) A: I know where **he** sent the letter.
b) B: Me too. To <u>Chuckie's</u> house.
b) A: I know where <u>Chuckie</u> sent the letter.
B: Me too. To <u>his</u> house.

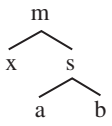
In each of the (a) examples, Principle C ensures that the pronoun (boldface, **he)** cannot be anaphorically linked to the underlined noun phrases (*Marcel, Chuckie, every pirate*). By contrast, the pronouns (*he, his*) can be anaphorically linked to the underlined noun phrases in the (b) examples, because Principle C does not apply to these strings of words. For example, (1b) can mean that Marcel said that he, himself, was the winner. The pronouns in both the (a) and the (b) examples can also have a deictic (direct) reference interpretation, but this is the only option for the (a) examples, since Principle C nullifies the anaphoric interpretation on which the pronoun and the underlined expression pick out the same referent.

21.2 Principle C

Examples (1) to (5) illustrate how Principle C governs the interpretations assigned to strings of words that contain nominal expressions (noun phrases).[1] One class of nominal expressions consists of referring expressions, which includes names (e.g. *Ted*) and definite descriptions (e.g. *the man over there drinking a martini*). According to Principle C, a referring expression cannot be anaphorically linked to a pronoun (or any other noun phrase)[2] if these two expressions are in a particular structural relationship (Chomsky 1981, 1986; Lasnik 1976).

Principle C is a negative principle in the sense that it enforces disjoint reference (non-coreference) between referring expressions and pronouns (see Endnote 2). Principle C is a syntactic principle, because its application is determined by the constituent structure that is assigned to strings of words. When a referring expression (hereafter, an R-expression) is in a particular structural relationship with a pronoun, coreference between them is banned by Principle C. The structural relationship is called *c-command*. C-command is schematically illustrated in diagram (A). This diagram represents the kind of constituent structure that children and adults assign to strings of words, according to the formalist approach (See Reinhart 1976, 1981).

(A)



C-command is stated using familial terms (*mother, sister, daughter, descendant*). In the diagram, *m* is designated as *x*'s *mother*, *s* is *x*'s *sister*, and *s* has two daughters, *a* and b. The daughters of *s* may have daughters of their own, but these daughters and other descendants do not appear in the diagram. We can now state c-command and Principle C more precisely:

C-command: A constituent *x* c-commands the descendants of *x*'s sister.

Principle C: An R-expression cannot be coreferential with a c-commanding noun phrase.

From these definitions, it follows that, if either daughter of *x*'s sister, *a* or *b*, is an R-expression, then it cannot be coreferential with *x*, because *x* c-commands both *a* and *b*.

Principle C governs the interpretations that can be assigned to the linguistic phenomena listed in examples (1) to (5) in the previous section. In several of these examples, Principle C applies to the constituent structure that is assigned to the string of words. In some examples, however, Principle C applies at a more abstract level of representation, called Logical Form.

21.3 Logical Form

Children's experience is limited to strings of words that are uttered (or signed) in conversational settings. Usually, the surrounding context makes these strings of words true on just one interpretation, eliminating potential ambiguity. The strings of words learners encounter do not come labeled with parts of speech or marked by phrase boundaries. Researchers working in the formalist approach contend, nevertheless, that child language learners project hierarchical structure (see diagram A) onto strings of words. The structure is created using a recursive operation called Merge (for discussion of children's knowledge of recursion, see Giblin et al. 2019).

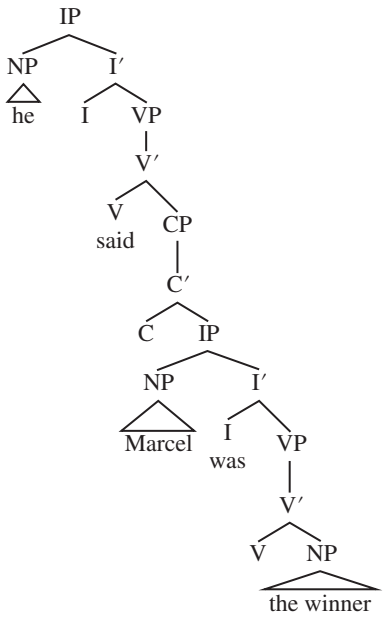
This chapter presents empirical findings that document children's assignment of hierarchical structure to strings of words. The empirical evidence we review supports a further conclusion – that child language learners access a level of linguistic representation in addition to the constituent structure that is formed using Merge. This additional component of the language apparatus is called Logical Form (LF). At Logical Form, strings of words are assigned a more articulated structure than the constituent structure formed by Merge. Logical Form extends the coverage of linguistic principles, including Principle C, enabling these principles to amalgamate linguistic phenomena that appear heterogeneous on the surface.

At LF, elements (e.g. noun phrases) can be moved to different positions. When an element moves to a different position, it leaves a copy behind. Most of the time, only the moved element is pronounced. However, if a copy of a moved referring expression (R-expression) is c-commanded by a pronoun, then Principle C enforces non-coreference between the pronoun and the R-expression. In this way, LF enables Principle C to apply to R-expressions that are not c-commanded by noun phrases in constituent structure.

Before we illustrate how Principle C operates at LF, we will illustrate how it operates at the level of constituent structure. Consider the string of words in (6). The constituent structure for (6) appears in diagram (B). Using the definition of c-command from earlier, we can see that the pronoun, *he*, c-commands the R-expression, *Marcel*, at constituent structure. One sister of the pronoun, *he*, contains the VP. The VP has several descendants, with the R-expression *Marcel* among them.[3] Therefore, Principle C prohibits coreference between the pronoun and the R-expression. Alternatively, we can say that Principle C enforces non-coreference or disjoint reference between expressions.

(6) *He said Marcel was the winner.*

(B)



Linguists indicate coreference and non-coreference using numerical indices, as in (7). Coreference between noun phrases is marked by assigning them the same numerical index. Conversely, non-coreference is marked by assigning them different indices.

(7) $\text{He}^{*}_{1/2}$ said Marcel_1 was the winner.

Notice that in (7), the pronoun has two subscripts, $he_{*1/2}$. Because the R-expression has been assigned the numerical index 1 ($Marcel_1$), the asterisk on the pronoun indicates that it cannot also be assigned index 1. However, a speaker can use the pronoun deictically, to refer to some salient male individual who is not mentioned in the sentence. The deictic (direct reference) interpretation of the pronoun is marked by the index 2. In sentence (8) the positions of the R-expression and the pronoun are reversed, as compared to (6).

(8) *Marcel said he was the winner.*
(9) Marcel_1 said $\text{he}_{1/2}$ was the winner.

As (9) reveals, repositioning the R-expression *Marcel* as in (8) leaves it free of any c-commanding noun phrases. Therefore (8) is not governed by Principle C, so coreference (co-indexation) between *Marcel* and the pronoun, *he*, is permitted. There is also a second interpretation of (8) on which the pronoun has direct reference.

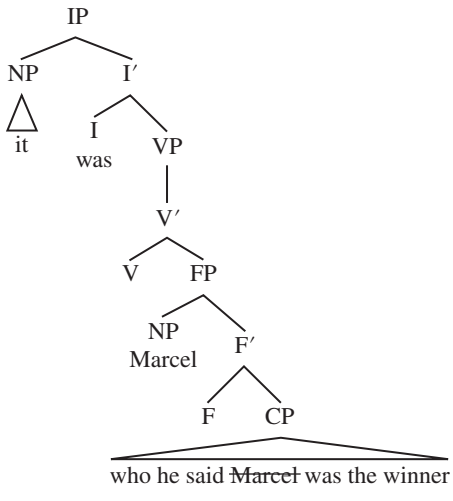
We will now illustrate how Principle C applies at the level of LF using the cleft sentence (10). We have provided a rough sketch of the LF for (10) in (11). At Logical Form, the R-expression, *Marcel*, has been moved to a Focus position following the words *It was* .... The copy of the R-expression, *Marcel*, is struck-out, leaving an unacceptable string of words: ... *he said was the winner*. To assign a semantic interpretation to (10),

the R-expression must be interpreted twice, once in the position it has moved to, and a second time in the position where it originated. Principle C enforces non-coreference between the pronoun and the R-expression, because it c-commands the copy of the R-expression that is left behind. This explains why the cleft sentence (10) is true in the same circumstances as the declarative sentence (12). Both sentences are true in circumstances in which a salient male individual (*he*) said that Marcel was the winner.[4]

(10) *It was Marcel who he said was the winner*.
(11) It was Marcel who [he said ~~Marcel~~ was the winner]
(12) *He said Marcel was the winner*. (Previous Example 6)

Although the LF in (11) gives the basics, a more articulated LF for the string of words in (10) is shown in (C).

(C)



Now consider (13). Here, the position of the pronoun and the R-expression have been reversed. We have sketched the LF for (13) in (14). Notice that the string of words, *Marcel said he was the winner*, is embedded in (14), though the copy of the R-expression is struck out. Neither the moved R-expression nor its copy are c-commanded by the pronoun in (14), so coreference is permitted in (13).

(13) *It was Marcel who said he was the winner*.
(14) It was Marcel who [~~Marcel~~ said he was the winner]

This section has shown how postulating a level of Logical Form extends the purview of Principle C. We now turn to studies of Principle C in child language.

21.4 Principle C in Child Language

Children's knowledge of Principle C has typically been assessed using an experimental technique known as the Truth Value Judgment Task (Crain and McKee 1985; Crain and

Thornton 1998; Thornton 2017). In this task, each child participant watches stories acted out with toys by one of two experimenters. The second experimenter plays the role of a puppet, who introduces the test sentences. The puppet's sentences describe the events that took place in the story. The task of the child participant is to indicate, both verbally and with a reward, when the puppet says "the right thing or the wrong thing." The truth value judgment task is designed to enable researchers to assess children's knowledge of linguistic principles that determine the meanings that can and cannot be assigned to sentences, as dictated by linguistic principles operative in the grammars of adult speakers.

In experimental investigations of Principle C, each trial sees two sentence meanings pitted against each other. Both meanings depict events that take place in the story. One meaning corresponds to the interpretation that is ruled out by Principle C. As we saw, Principle C rules out coreference between an R-expression and a pronoun that c-commands it. The story context makes the test sentence true if the child participant allows coreference between the R-expression and the pronoun. Child participants whose grammars lack Principle C are therefore expected to accept the test sentences as descriptions of the events that took place in the stories. On the other hand, if children cannot assign coreference to the noun phrases in the test sentences, then they are expected to reject the test sentences. The non-coreferential interpretation of the test sentences constitutes a false description of the events that took place in the story. In short, the stories are designed to make the target sentences false if children's grammars contain Principle C, but true if children's grammars lack Principle C. Like adults, children are expected to favor interpretations that make sentences true.[5] Therefore, the finding that children consistently reject the puppet's test sentences is evidence that children can only access a non-coreferential interpretation of the test sentences, as dictated by Principle C.

21.5 Declarative Sentences

Children's adherence to Principle C was first tested by Crain and McKee (1985). The Crain and McKee study presented sentences like (15) and (17) to the child participants.

(15) *He danced while the Ninja Turtle ate pizza.* Target
(16) $He_{*1/2}$ danced while the Ninja $Turtle_1$ ate pizza.
(17) *While he danced, the Ninja Turtle ate pizza.* Control
(18) While $he_{1/2}$ danced, the Ninja $Turtle_1$ ate pizza.

Sentences like (15) and (17) were presented to different child participants in the same context. In one story, the Ninja Turtle danced while he (the Ninja Turtle) was eating pizza. In that story, Robocop considered dancing but decided to lift weights instead. Sentences (15) or (17) were then produced by the puppet.[6]

First, consider the string of words in (15). The constituent structure assigned to (15) is governed by Principle C for English-speaking adults, because the pronoun, *he*, c-commands the R-expression, *the Ninja Turtle*. Therefore, coreference between the pronoun and the R-expression is blocked. If children's grammars incorporate Principle C, then they should be unable to assign a coreferential interpretation to (15). On the

only available interpretation of (15), the pronoun refers to Robocop. The story context makes (15) false on this interpretation. Principle C does block coreference between the pronoun and the R-expression in the control sentence (17), so it can mean that the Ninja Turtle danced and ate pizza – which is what happened in the story context. On the other hand, a child whose grammar lacked Principle C would permit coreference between the pronoun and the R-expression in (15). In this scenario, children would be expected to judge (15) to be a true description of the story context, because the Ninja Turtle danced while eating pizza. The Crain and McKee study tested 62 children with an average age of 4.2 years. The child participants rejected test sentences like (15) 88% of the time. By contrast, the same child participants accepted sentences like (17) 73% of the time.[7]

21.5.1 Cleft Sentences

We can now look at a string of words where Principle C applies at the level of Logical Form. Cleft sentences like (19) are one such case, as we saw earlier. As (20) indicates, the Logical Form associated with the string of words in (19) contains both a moved version of the R-expression, *Spot*, and a copy where it originated, following the verb *brushed*. Only the moved version of R-expression is pronounced, but in order to derive the semantic interpretation of (19), the copy of the R-expression must be "reconstructed" at its base position. Otherwise, the relative clause that contains the transitive verb *brushed* is missing an obligatory argument, … *that he brushed*. The LF for (19) is (20). At LF, the pronoun, *he*, c-commands the reconstructed copy of the R-expression. Therefore, Principle C applies to (19), ruling out coreference between the pronoun and the R-expression. The upshot is that (19) is true in the same circumstances as the declarative sentence (21), where Principle C applies at the level of constituent structure.

(19) *It was Spot that he brushed.* Target
(20) It was Spot that $he_{*1/2}$ brushed $\cancel{Spot}_1$
(21) *He brushed Spot.* Control
(22) $He_{*1/2}$ brushed $Spot_1$

An experiment by Thornton, Kiguchi, & D'Onofrio (2018) compared children's interpretations of sentences like (19) and (21). The experimental hypothesis was that the English-speaking child participants would reject a coreferential interpretation of both types of sentences equally often. If so, this would be taken as evidence that the child participants know that Principle C applies at the level of constituent structure for sentences like (21), and also applies at the LF level for sentences like (19).

The story was about Buzz the Bee, Spiderman, and the Pink Panther, who was training his dog Spot. After crawling through a large pipe full of leaves, they were all very dirty. Buzz and Spiderman asked Pink Panther to help them brush off the dirt. However, Pink Panther was anxious to keep training and only brushed the dirt off Buzz. Spiderman decided to stay dirty, and Spot used an extra cloth and managed to clean himself off. Following the story, the puppet produced either the target sentence or the control sentence, to different child participants. A child participant who allowed coreference between the pronoun, *he*, and the R-expression, *Spot*, was expected to accept both sentences because

Spot did brush himself off in the story. However, a child who was able to apply Principle C both at constituent structure and at LF should reject both the target sentence (19) and the control sentence (21) as descriptions of the events that took place in the story. This is exactly what the Thornton et al. study found. They interviewed 20 four- and five-year-old children with a mean age of 4;9. The child participants rejected the test sentences like (19) 94% of the time, and they rejected the control sentences like (21) 99% of the time.

21.5.2 Italian Sentences with Null Pronouns and Quantificational NPs

The majority of studies of Principle C in child language have been conducted in English. However, Principle C applies in other languages, including ones that differ from English in significant respects. We will review a representative study of Principle C in Italian, by Guasti and Chierchia (2000). The Guasti and Chierchia study investigated children's knowledge of Principle C at LF. The Italian sentences in the Guasti and Chierchia study differed from those used in English studies, so we will briefly review some of the relevant differences.

In contrast to English, pronouns are often omitted (not pronounced) in Italian, so Italian is classified as a "pro-drop" language. Nonetheless, a phonetically "invisible" pronoun is always assigned a referent in the conversational context. Importantly, if the position of the phonetically null pronoun c-commands an R-expression, then the referent assigned to the pronoun and the referent assigned to the R-expression cannot be the same. The R-expressions in the Guasti and Chierchia study were quantificational noun phrases, e.g. *ciascun pirata* "each pirate." These noun phrases were embedded in a preposition phrase (PP), e.g. *nel barile di ciascun pirate* "in each pirate's barrel." One of the test sentences was (23).

(23) *Nel barile di ciascun pirata con cura (pro) ha messo una pistola.*
In the barrel of each pirate with care (he) has put a gun
"He carefully put a gun in every pirate's barrel."

The English analogue to (23) is given in (24). In (24), the entire prepositional phrase (PP) has been moved to sentence-initial position from its base position in the verb phrase. The Logical Form for (24) is given in (25).

(24) *In each pirate's barrel, he put a gun.* Target
(25) In each pirate$_1$'s barrel, he$_{*1/2}$ put a gun ~~in each pirate~~$_1$~~'s barrel~~

Like the English verb, *put*, the Italian verb phrase *ha messo* "has put" takes two arguments. One of these arguments is satisfied by the moved PP. For (23) to be assigned a semantic interpretation, then, the moved PP must be reconstructed in its original position. As (25) reveals, the null pronoun in (23) c-commands the reconstructed copy of the PP. Therefore, Principle C dictates that the R-expression, *ciascun pirata* "each pirate" must be disjoint in reference from the pronoun. The only remaining interpretation is for the pronoun to have direct reference.

There were also control sentences in the Guasti and Chierchia study, similar to the controls in the original Crain and McKee (1985) study. In these sentences, the pronoun appeared in a *while* clause[8] and did not c-command the R-expression. As example (26) illustrates, the pronoun could either be anaphorically linked to the R-expression in the main clause, or it could be assigned direct reference.

(26) *Le scimmie hanno nascosto il tesoro di ciascun bambino, mentre dormiva*
The monkeys have hidden the treasure of each child, while (he) was sleeping.
"The monkeys hid every child's treasure while they were sleeping."

Italian-speaking children who adhere to Principle C at LF were expected to judge Italian sentences like (23) to be unambiguous, such that the (null) pronoun is assigned direct reference. If so, the child participants were expected to judge sentence (23) to be false as a description of a context where every pirate put a gun in his own barrel. On the other hand, the child participants were expected to judge sentences like (26) to be a true description of a context where every child's treasure was hidden by the monkeys when the children were sleeping.

The findings of the Guasti and Chierchia study were exactly as predicted. The child participants were 18 three- to five-year-old Italian-speaking children with an average age of 4;6. All of the children were presented test sentences like (23) and control sentences like (26) in a truth value judgment task. The control sentences were presented in different contexts. One condition verified the direct reference interpretation of the pronoun, and the other condition verified the interpretation where the pronoun was anaphorically linked to the R-expression. The ambiguous control sentences were accepted 89% of the time on the direct reference interpretation of the pronoun and 86% of the time on the anaphoric interpretation. By contrast, the child participants rejected the anaphoric interpretation of the test sentences like (23) 90% of the time. These findings support the proposal that Italian-speaking children apply Principle C at the level of Logical Form.

21.5.3 Crossover Questions

The previous study described a string of words in Italian, where the c-command relationship between a pronoun and an R-expression was disrupted in the constituent structure created by Merge. The disruption occurred because the prepositional phrase (PP) that contained the R-expression was moved to sentence-initial position. In order to apply Principle C, then, the displaced PP that contained the R-expression was reconstructed in its base position. A similar phenomena is witnessed in English.

In English, information-seeking questions are formed by movement of *wh*-words, such as *who, what, when, why,* or *where*. For example, in order to derive the semantic interpretation of the wh-word *who* in the information-seeking question, *Who did John laugh at?* the question-word *who* must be reconstructed in its base position following the preposition *at*: *Who did John laugh at who?*

Principle C applies to information-seeking questions when the *wh*-word "crosses over" a pronoun that has moved to sentence initial position. Such *wh*-questions are known as *crossover questions*. Crossover questions are governed by Principle C.

An example is (27). The R-expression, *Grover*, provides the answer to the indirect question (27). The copy of the *wh*-word, *who*, is analyzed as an R-expression. Therefore, if the pronoun, *he*, c-commands the copy of the *wh*-word *who*, then the pronoun and the *wh*-word cannot be anaphorically linked, eliminating the interpretation on which Grover said that he (Grover) has the best smile. According to Principle C, then, the pronoun in (27) must have direct reference. The Logical Form in (28) spells this out using numerical indices, as before.

(27) *I know who he said has the best smile. Grover.*
(28) I know who$_1$ he$_{*1/2}$ said ~~who~~$_1$ has the best smile. Grover$_1$.

According to the LF (28), the question/answer pair in (27) should be judged to be true in the same circumstances as the declarative sentence (29). Due to Principle C, neither (27) or (29) can be paraphrased as having the interpretation in (30).

(29) *He said Grover has the best smile.*
(30) *Grover said he, himself, has the best smile.*

The LF for the crossover question (27) is distinct from a superficially similar question (31). In contrast to the crossover question (27), the *wh*-word, *who*, the R-expression, *Grover*, and the pronoun, *he*, can all be anaphorically linked in (31). This is shown by the co-indexation of these expressions in the LF in (32).

(31) *I know who said he had the best smile. Grover.*
(32) I know who$_1$ ~~Grover~~$_1$ said he$_{1/2}$ has the best smile.

Sentence (31) is referred to as a *bound-pronoun* question. This bound-pronoun question is judged to be true in the same circumstances as sentence (30), *Grover said he, himself, has the best smile*. As a final note, the crossover question in (27) and the bound pronoun question in (31) contain exactly the same words. However, the word order differences (… *who he said* … versus … *who said he* …) engender different structural analyses and these, in turn, engender different interpretations.

A study by Thornton (1990) was designed to compare children's interpretations of crossover questions like (27), and bound-pronoun questions like (31). There were also declarative control sentences like (33).

(33) *He scratched Grover.*

The child participants in the Thornton study were 12 three- and four-year-old children with an average age of 4;2. The study used a version of the truth value judgment task in which the puppet supplied both an indirect question and its answer. In one condition, the crossover question/answer pair in (27) was presented to the child participants following a story about a competition to see who had the best smile. The judge of the competition was the previous year's winner. After considering each contestant, the judge decided that The Joker had the best smile. Grover was angry at the judge's decision and declared himself as the winner of the contest.

The findings confirmed the experimental hypothesis – that children would allow the pronoun and the R-expression to be anaphorically linked in sentences like (31), but not in crossover questions like (27). The child participants accepted the bound-pronoun

interpretation of sentences like (31) 50% of the time but rejected this interpretation of sentences like (27) 92% of the time. The rejection rate by the child participants for the crossover questions was similar to that of the declarative control sentences. For example, sentence (33) was rejected 95% of the time as a description of a story in which Grover scratched himself.

21.5.4 Discourse Sequences

Coreference is sometimes ruled out in discourse contexts. Consider (34), where Speaker A produces an indirect question that contains a pronoun and Speaker B supplies the detail missing from the assertion by Speaker A.[9] Notice that the R-expression mentioned by Speaker B cannot be coreferential with the pronoun mentioned by Speaker A. To explain the absence of coreference, it has been proposed that the discourse sequence (34) has a Logical Form like that in (35). On this account, the non-coreference facts in the discourse sequence are aligned with the non-coreference facts in the declarative sentence (36) – both facts are attributed to Principle C (Merchant 2005) (cf. Hankamer 1979; Morgan 1973, 1989).

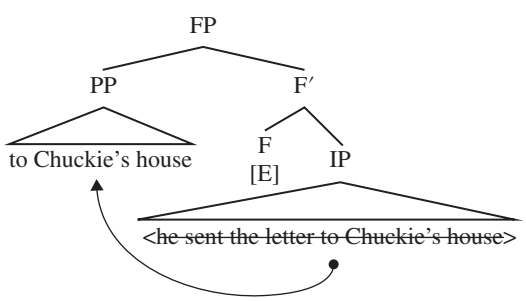
(34) Speaker A: *I know where he sent the letter*. Target: Session 1
Speaker B: *Me too. To Chuckie's house*.

(35) Speaker A: I know where $he_{*1/2}$ sent the letter.
Speaker B: Me too. To $Chuckie_1$'s house [~~$he_{*1/2}$ sent a letter to $Chuckie_1$'s house~~].

(36) *He sent a letter to Chuckie's house*. Target: Session 2

The diagram in (D) outlies the derivation of Speaker B's contribution to the discourse. At Logical Form, Speaker B reconstructs the structure of Speaker A's statement, filling in the answer to Speaker A's indirect question. The answer by Speaker B, *to Chuckie's house*, is a PP that has been moved to a focus position. The moved PP is reconstructed at its base position, where Principle C applies. Merchant (2005) proposes that a feature (called an E-feature for Ellipsis) instructs the speaker to omit the remainder of the sentence, leaving just the fragment answer, *to Chuckie's house*. The unpronounced structure is shown in brackets.

(D)



A study by Conroy and Thornton (2005) presented discourse sequences like (34) and declarative sentences like (36) to 20 four- and five-year-old English-speaking children. There were two sessions. The average age of the children in the first session was 4;6

and the average age of the children in the second session was 4;10. The first session incorporated question/answer pairs in which the R-expression in the question produced by Speaker A was coreferential with a pronoun in the answer produced by Speaker B. This kind of discourse sequence is illustrated (37). In the second session, a pronoun used by Speaker A was coreferential with an R-expression used by Speaker B, as illustrated by the discourse sequence in (38).

(37) Speaker A: I know whose cup Chuckie$_1$ threw. Control: Session 1
Speaker B: Me too. His$_1$ cup.

(38) Speaker A: I know whose present his$_1$ mother bought. Control: Session 2
Speaker B: Chuckie$_1$'s present.

In the story associated with the discourse sequence in (34), Chuckie had just moved to a new house. He was upset that he had not received any mail. Chuckie asked his friend Tommy to send him a letter, to make sure mail was being delivered to the house. Tommy said he would send a letter, but he couldn't find a stamp and then he misplaced the letter. Chuckie remained concerned, so he wrote a letter and posted it to the new house. The letter arrived the next day. The child participants rejected declarative sentences like (36) 86% of the time as descriptions of this story context. The child participants also rejected discourse sequences like (34) 89% of the time. By contrast, children accepted control sequences like (37) 88% of the time in the first session, and they accepted control sequences like (38) 84% of the time in the second session.

21.6 Conclusion

This chapter reviewed experimental evidence demonstrating that child language learners of four or five years of age apply Principle C to five disparate-looking linguistic phenomena. It is not immediately apparent that these phenomena are governed by the same principle, because they assume different guises: information-seeking *wh*-questions, declarative statements, and discourse sequences. However, it turns out that Principle C amalgamates these disparate-looking linguistic phenomena, providing unity in the face of apparent diversity. In each case, young children were found to consistently adhere to Principle C, rejecting sentences as descriptions of situations that did not conform to this principle. The absence of negative evidence informing children that certain interpretations are precluded by linguistic principles, such as Principle C, makes it highly implausible that children have learned through experience which interpretations cannot be assigned to sentences in the local language. Furthermore, there is no suggestion from this set of empirical evidence that children are learning how to interpret these structures one by one, since they gave robust rejections of interpretations that would violate Principle C in every structure. The alternative is to suppose that children have innate knowledge of linguistic principles that govern semantic interpretation, as proposed by Noam Chomsky.

Endnotes

1 Principle C is the third principle of a component of Universal Grammar called Binding Theory. Binding theory is concerned with the acceptability and interpretation of different kinds of nominal expressions, including ordinary pronouns like *him* and *her*, reflexive pronouns like *himself* and *herself,* and reciprocal expressions like *each other* (Chomsky 1981).

2 Principle C states that a referring expression cannot be anaphorically related to any kind of noun phrase when the two are in a particular structural relationship. We limit the discussion in the present chapter to strings of words that contain pronouns and referring expressions.

3 Triangles indicate that there is further internal structure for these noun phrases, not shown in the diagram.

4 Example (10) has a meaning component beyond that of (6). This is the presupposition that the salient male individual (*he*) had claimed that *someone* was the winner. The string of words in (10) adds the new information that Marcel is that person (the s*omeone* of the presupposition).

5 The preference to access interpretations that make sentences true is called the Principle of Charity (Davidson 1984).

6 The puppet preceded the test sentences and control sentences with a lead-in sentence that named the characters and summarised the theme of the story context: "That was a story about Robocop and the Ninja Turtle . . . ."

7 The Crain and McKee study also included contexts that made both the control sentences true. In the context for sentence (2), Robocop danced while the Ninja Turtle ate pizza. The child participants accepted sentences on this interpretation 81% of the time.

8 This structure is known in the literature as a Clitic Left Dislocation structure.

9 The *Me too* filler before Speaker B's answer was inserted to make clear that a different speaker was taking a turn in the conversation.

References

Ambridge, Ben, and Elena V. M. Lieven. 2011. *Child Language Acquisition: Contrasting Theoretical Approaches*. Cambridge: Cambridge University Press.

Brown, Roger, and Camille Hanlon. 1970. Derivational complexity and order of acquisition in child speech. In *Cognition and the Development of Language*, edited by John R. Hayes, 11–53. New York: Wiley.

Bowerman, Melissa. 1988. The no-negative evidence problem: How do children avoid constructing an overly general grammar? In *Explaining Language Universals*, edited by John. A Hawkins, 73–101. Oxford: Blackwell.

Chomsky, Noam. 1965. *Aspects of the Theory of Syntax*. Cambridge: MIT Press.

Chomsky, Noam. 1981. *Lectures on Government and Binding*. Dordrecht: Foris Publications.

Chomsky, Noam. 1986. *Knowledge of Language: Its Nature, Origin and Use*. New York: Praeger Publishers.

Conroy, Anastasia, and Rosalind Thornton. 2005. Children's knowledge of Principle C in discourse. In *Proceedings of the Sixth Tokyo Conference on Psycholinguistics*, edited by Yukio Otsu, 69–94. Tokyo: Hituzi Syobo Publishing Company.

Crain, Stephen. 1991. Language acquisition in the absence of experience. *Behavioral and Brain Sciences* 14: 597–612.

Crain, Stephen, and Cecile McKee. 1985. The acquisition of structural restrictions on Anaphora. In North East Linguistic Society *16, edited by Stephen Berman, Jae-Woong Choe, and Joyce McDonough*, 94–110. Amherst, MA: GLSA.

Crain, Stephen, and Rosalind Thornton. 1998. *Investigations in Universal Grammar: A Guide to Experiments on Syntax and Semantics*. Cambridge: The MIT Press.

Dabrowska, Ewa. 2015. What exactly is Universal Grammar, and has anyone seen it? *Frontiers in Psychology* 6. http://dx.doi.org/10.3389/fpsyg.2015.00852

Davidson, Donald. 1984. *Inquiries into Truth and Interpretation*. Oxford: Oxford University Press.

Evans, Nicholas, and Stephen C. Levinson. 2009. The myth of language universals: Language diversity and its importance for cognitive science. *Behavioral and Brain Sciences* 32: 429–492.

Giblin, Iain, Peng Zhou, Cory Bill, Jiawei Shi, and Stephen Crain. 2019. The spontaneous eMERGEnce of recursion in child language. In *the Proceedings of the 43rd Annual Boston University Conference on Language Development (BUCLD)*, edited by Megan M. Brown and Brady Dailey, 270–285. Somerville, MA: Cascadilla Press.

Gold, E. Mark. 1967. Language identification in the limit. *Information and Control* 10: 447–474.

Goldberg, Adele. 2003. *Constructions at Work: The Nature of Generalizations in Language*. New York: Oxford University Press.

Guasti, Maria Teresa, and Gennaro Chierchia. 2000. Backward versus Forward Anaphora: Reconstruction in Child Language. *Language Acquisition* 8: 129–170.

Hankamer, Jorge. 1979. *Deletion in Coordinate Structures*. Outstanding Dissertations in Linguistics. New York: Garland Publishing.

Ibbotson, Paul. 2013. *The scope of usage-based theory. Frontiers in Psychology* 4. DOI: 10.3389/fpsyg.2013.00255

Lasnik, Howard. 1976. Remarks on coreference. *Linguistic Analysis* 2: 1–22.

Marcus, Gary. 1993. Negative evidence in language acquisition. *Cognition* 46: 53–85.

Merchant, Jason. 2005. Fragments and ellipsis. *Linguistics and Philosophy* 27: 661–738.

Morgan, Jerry. 1973. *Sentence fragments and the notion "sentence." In Issues in Linguistics, edited by Braj Kachru, Robert Lees, Yakov Malkiel, Angelina Pietrangeli and Sol Saporta*, 719–751. Urbana: University of Illinois Press.

Morgan, Jerry. 1989. Sentence fragments revisited. In *Proceedings of Chicago Linguistic Society 25, Parasession on Language in Context*, edited by Bradley Music, Randolph Graczyk, and Caroline Wiltshire, 228-241. Chicago: Chicago Linguistic Society.

Pinker, Steven. 1984. *Language Learnability and Language Development*. Cambridge: Harvard University Press.

Reinhart, Tanya. 1976. *The Syntactic Domain of Anaphora*. PhD dissertation, MIT.

Reinhart, Tanya. 1981. Definite NP anaphora and C-command domains. *Linguistic Inquiry* 12: 605–635.

Thornton, Rosalind. 1990. *Adventures in long-distance moving: The acquisition of complex Wh-questions*. PhD dissertation, University of Connecticut.

Thornton, Rosalind. 2017. The truth value judgment task: An Update. In Studies in Chinese and Japanese Language Acquisition: Studies in Honor of Stephen Crain, edited by Mineharu Nakayama, Yiching Su, and Aijun Huang. Amsterdam: John Benjamins [Language Acquisition and Language Disorders Series].

Thornton, Rosalind, Hirohisa Kiguchi, and Elena D'Onofrio. 2018. Cleft sentences and reconstruction in child language. *Language* 94: 405–431.

Tomasello, Michael. 2000. Do young children have adult syntactic competence? *Cognition* 74: 209–253.

Tomasello, Michael. 2003. *Constructing a Language: A Usage-Based Theory of Language Acquisition*. Cambridge, MA: Harvard University Press.

22

Chomsky and Signed Languages

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22.1 Introduction and History

Chomsky's "revolution" and the revolution in sign language linguistics (Lillo-Martin 2018) began around the same time, but they did not directly affect each other for a while. Before the publication of William Stokoe's *Sign Language Structure* (Stokoe 1960), the natural sign languages of deaf communities were generally thought to be conglomerations of unstructured gestures and/or manual representations of spoken languages (although acknowledgment of the existence of natural signs goes back at least to Plato, and various scholars and users of sign languages recognized that they are rule-governed well before Stokoe's time). Stokoe's work, published in the University of Buffalo's *Occasional Papers*, reflected his training by Trager and Smith in structural linguistics and put forward an analysis of American Sign Language (ASL) undertaken in that vein. His proposals, that signs have parts and that signs are organized in grammatical ways, were not immediately embraced: a review of Stokoe's monograph published in *Language* was extremely negative (Landar 1961). Nevertheless, his work seems to have been more rapidly adopted in the linguistics community than by most of his own colleagues at Gallaudet College (now University); according to Eastman (1980), Stokoe's claims were ridiculed by many at his institution, but he had funding from NSF, and with deaf colleagues produced a widely recognized dictionary with grammatical information (Stokoe, Casterline, and Croneberg 1965). By 1966 he was invited to give a presentation to the Georgetown University Round Table.

Stokoe himself was not enthusiastic about the application of generative grammar to sign languages in the early years (Tweney and Hoemann 1976), and never warmed up to it (Stokoe 1990). He emphasized the need to study the people who used a language and not focus on competence as an independent mental phenomenon. Still, the revolution he started was not immune from the influence of generative grammar, despite his own reluctance.

Linguistic research on sign languages in the 1960s and 1970s spread from Stokoe's Linguistics Research Laboratory at Gallaudet, with numerous researchers in the

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Washington, DC, area, others at Berkeley, and the establishment in 1970 of the Laboratory for Language and Cognitive Neuroscience at the Salk Institute in La Jolla, CA, led by Ursula Bellugi and her husband, Edward S. Klima. Bellugi had completed her doctoral work with Roger Brown at Harvard, and Klima was a generative syntactician at MIT before moving to the University of California at San Diego. Bellugi and Klima's work on sign languages was therefore strongly influenced by Chomsky and his theories of generative grammar in a general way. They were very interested in understanding the linguistic rules underlying ASL, which they approached through analysis of data from native signers (using elicitation and judgment studies), psycholinguistics, acquisition, and studies of breakdown in signers with aphasia. While their work is very compatible with generative ideas, their focus in ASL analysis was not on specific generative mechanisms. However, as the following sections will demonstrate, numerous sign language scholars who were themselves mentored by Bellugi and Klima made specific contributions to generative analyses of sign languages, and/or connections to Chomsky's proposals about innateness.

The next two sections of this chapter will focus on Chomsky-inspired research on sign language grammar and the ways that the study of sign languages connects to theories of innateness, the two main ways that Chomsky's impact has been felt in sign linguistics. The final section will discuss implications of these findings.

22.2 Syntax and Modularity

What do Chomsky's theories of syntax say about sign languages? Chomsky himself says very little about sign languages. In his early works, sign languages aren't mentioned. Later, they occasionally come up, in a kind of acknowledgment of existence, but he makes no claims about how sign language grammars might work other than his claims about grammar in general. Specifically, in later works when he discusses the articulatory-perceptual or sensory-motor interface – and especially in the context of discussions of language evolution – he includes the option that this component involves sign languages. For example, in support of the argument that language is not coextensive with speech, Bolhuis, Tattersal, Chomsky, and Berwick (2014) state, "However, speech and speech perception, while functioning as possible external interfaces for the language system, are not identical to it. An alternative externalization of language is in the visual domain, as sign language; even haptic externalization by touch seems possible in deaf and blind individuals" (Bolhuis et al. 2014, 1; see also Chomsky 2011). Hauser, Chomsky, and Fitch (2002) even include an image of a person using a sign language.

Numerous scholars have adopted the assumption that specific proposals made within the generative tradition ought to, then, apply to sign languages as well as spoken languages, from as early as the 1970s up to the current time. For example, Susan D. Fischer wrote what is considered the first generative syntactic analysis of a sign language (Fischer 1974). Her paper provided an *Aspects*-style transformational account of word order in ASL, including an argument that the Complex NP-constraint of Ross (1967) holds of rules for sentence topicalization and NP-backing (backgrounding). This paper led a group of sign linguists to decide that they no longer needed to make the argument that sign languages are real language, the point having been demonstrated so conclusively, as noted by Ronnie Wilbur in the Editor's Preface to the reprinting of

Fischer's paper (Fischer 2009). Over decades, Fischer contributed numerous additional generative analyses, including work on word order change, verbal morphology, and a parametric X'-theoretic approach to what she called "mini-topicalization," among many others (Fischer 1975, 1990; Fischer and Gough 1978).

Another early and influential work employing generative theory for the analysis of sign language data was that of Scott K. Liddell (Liddell 1980). Liddell's book thoroughly examined previous claims that ASL lacked subordination and other syntactic features. He pointed out that non-manual components – specific configurations of facial features, head position, and body movements – are often associated with specific syntactic structures, possibly accounting for why they had previously been overlooked. He proposed that non-manual markers exist in the phrase structure of a sentence and spread over command domains (Langacker's version, pre- c-command). Variants of his proposal have been taken up by later scholars, particularly Neidle et al. (1998, 2000), who argued that the spread of non-manuals over c-command domains reveals syntactic structure.

More researchers made generative proposals regarding sign languages in the 1980s (and beyond). Judy Shepard-Kegl (for whom Chomsky was a dissertation co-supervisor) proposed a detailed sublexical structure for ASL signs, and associated with that, she gave generative analyses of a number of phenomena, including clitics, pronouns, agreement, and null arguments (Shepard-Kegl 1985; Kegl 1987, 2003). Carol Padden (Padden 1983), worked within the framework of Relational Grammar, which was an alternative to Chomsky's proposals but maintained numerous foundational aspects of generative grammar and was clearly influenced by him. Padden identified three groups of verbs in ASL according to the types of inflectional morphology they accept; this tri-partite division is adopted by most sign linguists to this day. Padden also proposed specific structural configurations used in ASL and provided syntactic arguments to identify subjects, embedded clauses, and other structures. I myself used the generative approach of the Principles and Parameters theory to propose that null arguments in ASL have multiple analyses, including *pro* under licensing by agreement, and null topics in other configurations (Lillo-Martin 1986).

Starting in the 1990s, more researchers were using generative approaches to sign languages, and a greater variety of sign languages were represented. It's not possible to review all such research here, but mention should be made of a few examples. Ronnie B. Wilbur published a series of works applying generative theory to the analysis of various sentence types in ASL, including information structure-influenced word order variations, clefts, and operator-variable structures (e.g. Wilbur 1991, 1997; Wilbur and Patschke 1999). Wilbur was active in sign language research from the 1970s, and the domain of topic areas she has contributed to is quite impressively broad.

A group of researchers associated with the American Sign Language Linguistic Research Project at Boston University conducted a series of studies cumulating in a book published by MIT Press (Neidle et al. 2000). This work used the spread of nonmanual markers as a key to determining hierarchical structure of ASL, and argued that in ASL, the specifier of CP is linearly on the right side, in order to account for sentence-final *wh*-words in direct questions. This viewpoint was challenged by Petronio and Lillo-Martin (1997), who argued that sentence-final *wh*-words are focused elements, noting the presence of other focused elements in sentence-final position, and by Quadros (Quadros 1999; Nunes and Quadros 2006), who made a similar argument

but used a very different derivation for analogous structures in Brazilian Sign Language (Libras). Debate over the analysis of *wh*-questions and the position of [Spec, CP] has continued, with an important contribution from Cecchetto, Geraci, and Zucchi (2009), who argued that Italian Sign Language (LIS) also has rightward *wh*-movement, and that it is the unique role of nonmanual marking that leads to sign languages using this structure. LIS is different from ASL in its basic word order (SOV) and the pattern of *wh*-question types allowed is also different, so caution is needed in extending the specifics of the analysis. However, the possibility that the existence of nonmanual marking in sign languages leads to different hierarchical structures in comparison to spoken languages is an important consideration.

Since the 1990s, researchers taking a generative approach to sign languages have included a wider range of scholars looking at sign languages other than ASL. One such sign language is Libras, as mentioned earlier (Quadros). There is a very active group of Italian researchers, as already mentioned (including Cecchetto, Donati, Geraci, Zucchi); there are also scholars in Germany (Steinbach), the Netherlands (Pfau), Barcelona (Quer), and Turkey (Kelepir). In addition to many studies of phenomena in specific sign languages, this group has been engaged in various cross-linguistic studies of sign languages, with several very productive collaborative outcomes (Pfau, Steinbach, and Woll 2012; Quer et al. 2017). In Asia, there is an active group at the Chinese University of Hong Kong (Tang), and more recently, several generative scholars in Japan (Kawasaki, Matsuoka).

Currently, as in Stokoe's time, the field of sign linguistics is split between those who adopt formal (typically generative) approaches and those who eschew the distinction between competence and performance (typically cognitive/ functionalist). The field is still small enough that we naturally learn from each other and frequently meet together, although there are now regular periodic conferences devoted to each perspective separately (FEAST: Formal and Experimental Advances in Sign language Theory; and Sign CAFÉ: Cognitive and Functional Explorations in sign language linguistics). Major handbooks, collections, volumes, and reviews are often focused on generative works or at least include them (Neidle et al. 2000; Sandler and Lillo-Martin 2006; Brentari 2010; Pfau, Steinbach, and Woll 2012; Fischer 2017; Quer et al. 2017). All this ensures that Chomsky's influence continues to be felt in sign linguistics.

Given Chomsky's presentation of his conception of the interfaces, it can be presumed that there should be a core of syntactic rules and representations plus words that might be independent of modality; modality factors belong to the external sensory-motor interface. However, this is not to say that there is no influence on the core from an interface. Chomsky (2011, 273–74) spells it out: "The sensory-motor (SM) interface of course requires some kind of ordering (depending on the modality, e.g. different for speech vs. sign)." Then, there is a possibility for modality effects within Chomsky's conceptualization of a language architecture that encompasses both speech and sign.

Consideration of potential modality effects has been a central concern of sign linguists. From the beginning, it was important to establish that sign languages are like spoken languages in many core ways, to give them the legitimacy they were lacking in too many places. And there are many, many similarities across signed and spoken languages (see Sandler and Lillo-Martin 2006 for a summary). Yet, there are also differences, and these have been of special interest for the light they can shed on where putative universals are deep, and where they are limited to a single modality (Meier, Cormier, and Quinto-Pozos 2002; Lillo-Martin and Gajewski 2014).

Let us consider a frequently cited example. In sign languages, (co-)reference can be achieved through pointing. A signer may point to a referent who is present in the discourse context (e.g. the addressee), or to a locus in the signing space that is used to represent a referent. These pointing signs are generally considered to be pronouns (although see Koulidobrova and Lillo-Martin 2016 for an argument that at least some are better analyzed as demonstratives). Because the pointing sign usually picks out a specific referent, rather than a class of potential referents such as third-person females (cf. English "she"), it is usually unambiguous. Furthermore, there is no way to list all the possible instantiations of the pointing sign plus the location it is directed to. This phenomenon would appear to be a modality effect. Spoken languages do not have an analogous system; they may have means to refer to an element from a relatively small class (e.g. Bantu noun classes), but the sign language forms are unique in pointing to a specific referent. Nevertheless, it has been argued that the sign language pronominal system adheres to grammatical principles that have been proposed to govern pronouns, such as Binding Condition B, crossover, etc. (see Sandler and Lillo-Martin 2006). Sign linguists have made various proposals to account for those aspects of the system that make it modality-unique, but many of them do so while attempting to maintain the commonalities between sign language pronominal and demonstrative systems and those of spoken languages (see, e.g. Lillo-Martin and Klima 1990; Steinbach and Onea 2016; Schlenker 2018).

Some researchers have taken the existence of modality effects to be evidence against a strongly modular conception of the language faculty. Sandler (1993) focuses on the Fodorian (Fodor 1983) rather than the Chomskian concept of modularity. She interprets Fodor's claim that language, as a modular system, is domain-specific, as limiting the language domain to speech (based on the fact that Fodor uses empirical arguments from the study of spoken language). Fodor himself expressed the opinion that "domain" should be interpreted abstractly (Mattingly and Studdert-Kennedy 1991, 369–370), and I agree that the existence of languages in the visual/manual modality is not in itself evidence against the modularity hypothesis (whether Fodorian or Chomskian). Rather, I see the core question of domain-specificity to be whether specifically linguistic principles are necessary to account for the properties of language (spoken or signed), or whether general cognitive principles suffice. This issue continues to be debated, and inclusion of sign languages in the empirical dataset bearing on it is crucial, to check whether any putative universals that are specific to the language domain are also modality-independent.

22.3 Acquisition and Emergence

Chomsky's linguistic legacy has two primary arms: one in theories of syntax, and the other in theories of language acquisition. Chomsky's strong claim is that the input provided to young children acquiring their native language is too poor to constitute a complete inductive basis for general cognitive learning principles to succeed. Ergo, some mechanisms for language learning must be domain-specific, and innate. Specifying the content of this "language acquisition device" has been a central concern of Chomskian linguistics.

Evidence can be gleaned from sign language acquisition that is parallel to that exhibited from the study of spoken languages (cf. chapter 21 of this volume). For example, children may display knowledge of the ungrammaticality of strings that

might be expected to be grammatical, given the existence of similar strings in a paradigm – the archetypical case of knowledge in the absence of experience (Crain 1991). Sign language acquisition studies can also be used to test specific theories, such as Chomsky's proposal that acquisition involves selecting the target setting on parameters of cross-linguistic variation (for an example of parameter-setting in ASL, see Lillo-Martin 1991). However, studies of sign language development are also able to contribute uniquely to the question of how children go beyond the input, because of the regrettable fact that many deaf children receive poor-quality input, or indeed very little accessible linguistic input of any kind.

First, it must be asserted that when children do have fluent, accessible signed input from birth, their course of language development is remarkably parallel to that seen in children developing spoken languages (for overviews, see Chen Pichler 2012; Lillo-Martin 2016; Chen Pichler et al. 2018). So, we shouldn't expect that deafness, or the fact that the language being acquired is manual/visual, would necessarily lead to a radically different developmental path in comparison to hearing children learning a spoken language. What could lead to a different path is striking inadequacy of the input.

Only about 5% of deaf children born in the United States have deaf parents who use a sign language (Mitchell and Karchmer 2004). These are the participants in the research briefly described above. However, even for these children, their deaf parents are not likely to have been exposed to a sign language from birth themselves. Although they may have been using ASL as their primary language for many years, if they were later learners, they may show irregularities in their use of some grammatical structures (see the following discussion). What does the child's acquisition look like if the parents' use of some structure is inconsistent?

This question was investigated in a study by Singleton and Newport (2004). They looked at a domain of ASL grammar that was known to be inconsistently mastered by late learners: the complex morphology of verbs of motion (sometimes known as verbal classifier constructions). They studied one seven-year-old deaf child ("Simon") and his deaf parents, who were late learners of ASL, and the primary providers of input in ASL to their son. What they found was that, as expected, the parents performed rather poorly on their test, like other late learners; in contrast, Simon performed at much higher rates of accuracy, surpassing the scores of his parents, and performing similar to deaf native signer peers.

On the basis of extensive analysis of the response patterns from Simon and his parents, Singleton and Newport conclude that he uses "frequency boosting" to select the most consistent forms used by his parents, and then regularizes them. They describe this process as one that might work in domains outside of language; yet, given that many other possible learning mechanisms would not account for this pattern of results, they endorse the suggestion that "an outcome of this kind would support the claim that children acquire languages at least in part by virtue of innate constraints on the possible form of grammatical rules" (Singleton and Newport 2004, 403).

Simon's input in ASL was degraded due to the delayed acquisition of ASL that his own parents had gone through; yet, he did receive signed input from birth. However, most of the time, when a deaf child is born to hearing parents, the parents have little to no knowledge of sign languages or the deaf community. They receive advice from doctors and educators, and in many cases they delay providing sign language input, whether because they have consciously adopted a philosophy stressing spoken language

and denying sign input or because they simply need time to go through their own process and start to learn ASL or another natural sign language, or find alternative input sources for their child. What happens when such children are eventually exposed to ASL? What do they do in the meantime?

A number of studies have investigated sign language development by late learners: people whose training in spoken language was less than fully successful, who then were exposed to a sign language. Most of these studies consider such learners as late first-language (L1) learners, even though they were exposed to spoken language training through an oral education. Most such studies are conducted with adults, years after the start of their exposure, to see what the outcomes of such delayed L1 acquisition are.

In their comprehensive overview of such studies, Mayberry and Kluender (2018) argue that late L1 exposure to a sign language provides a clear test of the critical period hypothesis: the proposal that there is a critical (or sensitive) period within which language input must be supplied for the typical language acquisition process to proceed. The claim that language development is subject to a critical period is often taken as evidence in support of a Chomskian style nativism. However, it is important to recognize that Chomsky's nativism proposals do not necessarily predict the existence of a critical period; nor would conclusive evidence that there is no critical period be contra-evidence to nativist ideas.

The idea of a critical period is compatible with both language-particular, innate learning mechanisms and general-purpose learning mechanisms, either of which could decline or change over time. That said, the results presented by Mayberry and Kluender, and by many others, show clearly that initial exposure to a first language after the first few years of life has long-lasting effects. Mayberry and Kluender also argue that the evidence from second-language acquisition is much more equivocal. They conclude that it is studies of deaf people, who are the only ones likely to experience a delay in accessible first-language exposure, that are crucial to better understand which aspects of language are affected by delays of different lengths.

We've discussed absence of experience as illustrated by grammatical phenomena, and poverty of the stimulus as illustrated by lower-quality or delayed input. What happens during the time that deaf children are experiencing a complete lack of naturally accessible input? Remarkably, they self-generate a system that has many of the characteristics of natural language. Such systems are known as *homesign,* and they have been intensively investigated by Susan Goldin-Meadow and her colleagues (as summarized in Goldin-Meadow 2003). Goldin-Meadow herself has refrained from making the claim that the results of her research provide support for innate, language-specific knowledge of the type that Chomsky proposes, preferring to characterize the linguistic characteristics she observes as "resilient" properties. However, the observations made by her and by others that homesigners produce structures that display characteristics including gesture-internal structure (Brentari et al. 2012), specific patterns of sign order (Goldin-Meadow and Mylander 1998), and recursion (Goldin-Meadow 1982), among many others, indicates that not only do language learners develop based on external forces of input but they also bring to bear powerful language-learning mechanisms that permit them to make use of complex structures found in all natural languages.

In some contexts, homesigners become adults without being exposed to a natural sign language. These adult homesigners may have a limited network of family members and friends with whom they communicate using their self-generated system. While researchers have found that adult homesign systems may display some complexities

even beyond those of children, there are still some limitations. For example, a study of adult homesign systems in Nicaragua found that they display evidence of grammatical subjects that can be differentiated from topics (Coppola and Newport 2005). However, although homesigners might use their system to interact with others over many years, when close conversation partners are tested on their comprehension of homesigner productions in the absence of context, they do very poorly (Carrigan and Coppola 2017); and even the lexicons they use are not stable and not strongly shared between the various conversational partners of a single homesigner (Richie, Yang, and Coppola 2014). Based on studies of homesigners, both children and adults, two points can be emphasized (cf. Morford and Wood 2016). First is the observation of "resilience," or the appearance of many language-like characteristics and properties in the absence of experience. Under a Chomskian view, these can be considered manifestations of the language acquisition device. Second, without input from a community that shares a language, learners can only go so far on their own in developing their own language-like system.

Rarely, researchers have the opportunity to observe what happens when isolated homesigners form their own community. When educational programs for deaf children were established in Managua in the 1970s, deaf children who had previously not had contact with one another came together. Although the programs used the oral method and did not teach using sign language, as could be expected the children used their self-generated systems with each other, and over time a natural language emerged. Researchers have been documenting this over some decades (Kegl, Senghas, and Coppola 1999; Senghas 2003), discovering which linguistic properties emerge immediately and which take one or two cohorts (about 10 years each) for those who've been using the language for a while to pass it down to the younger, newer community members (Kocab et al., under review). Either way, the emergence of Nicaraguan Sign Language has been incredibly rapid, and its grammatical properties have been changing very quickly, in comparison to the methodical pace of language change in established languages. Again, a Chomskian interpretation of these findings would emphasize that core linguistic characteristics following from universal grammar require triggering, but not multiple generations of community interactions to slowly develop.

22.4 Consequences and Implications

Sign languages, we've seen, are like spoken languages, and yet they are also very different. Although Noam Chomsky himself hasn't attempted to bring data specifically from sign languages into his theories, it seems, especially from the later papers, that the conclusion drawn here would not be surprising for him or under his approach. The generative model, such as its representation in Berwick et al. (2013), hypothesizes both a syntactic component of rules, representations, and words, which could be expected to be largely the same (abstractly) across modalities, as well as an external sensory-motor interface, by which phenomena that are tied to a particular modality can be anticipated. This is not to say that anything goes; expected modality effects are constrained under certain views of modularity (for further discussion, see Lillo-Martin 1997, 2002; Lillo-Martin and Gajewski 2014).

This chapter has touched on some of the ways that data from sign languages can bear on generative theoretical proposals. For one thing, the very existence of hierarchy is clearly replicated in sign languages, including the crucial role that concepts such as

c-command play, as noted earlier in the context of the spread of nonmanual markers. On the other hand, the nature of linearization may be different, given the variety of simultaneous expressions allowed in sign languages (see Kimmelman 2017 for one example). Recent work has also addressed the application of the notions *Merge* and *Agree* in sign languages (e.g. Pfau, Salzmann, and Steinbach 2018; Lourenço and Wilbur 2018). Sign languages have moved into mainstream generative linguistics as languages that should be consulted when universal concepts of language are considered.

Evidence from signers also calls into question the idea that language and other cognitive domains are completely distinct modules. This evidence comes from observations of negative cognitive effects associated with delayed linguistic access. Connections between early language deprivation and cognitive consequences can be observed in several ways. For example, adult homesigners in Nicaragua do not perform in adult-like ways on tests of Theory of Mind (Pyers and Senghas 2009) or number cognition (Spaepen et al. 2011). Children who have experienced delayed language access may show negative consequences in Theory of Mind (Gale et al. 1996), Executive Function (M. L. Hall et al. 2018), numeracy (Contreras et al. 2018), and other cognitive domains. These observations and others about cognitive functions that rely on healthy language development require a rethinking of the modularity hypothesis, if modularity is taken to mean that language and cognitive development are entirely independent. Whereas evidence of dissociations between language and cognitive development in extreme cases has been given as evidence for a modular approach (Curtiss 1988), it is also possible that experience with language builds up what Fodor called *horizontal faculties*, including the computational and symbolic resources that are required for successful performance in multiple domains. On the other hand, it's also possible that such a strong view of modularity is simply wrong. Further consideration is required.

Chomsky's insistence on the point that children acquire language under conditions of poverty of the stimulus has been debated in the context of hearing children learning a spoken language (see, for example, articles in a special issue of *The Linguistic Review 19(1–2)*, published in 2002). Chomsky's theory doesn't say that no input is required for language to emerge; else how would a child internalize the grammar of the language used around them? Yet, his focus is on the "ideal speaker/hearer" and the "idealization to instantaneous acquisition" (Chomsky 1965, and many other works). In the real world, acquisition is not instantaneous, and children (hearing or deaf) require input and a community sharing an accessible language.

Children who cannot access spoken language and are not exposed to a natural sign language are surely in conditions of stimulus poverty. What is remarkable is that some properties of language nevertheless emerge, due to the intense drive to acquire a language. But despite the possibility for developing aspects of a language-like communicative system without accessible input, this kind of stimulus poverty leads to long-lasting negative effects on language and cognitive development. Importantly, whatever theories say about children's linguistic resilience, language deprivation does hurt and must be avoided (W. Hall 2017; M. L. Hall, Hall, and Caselli 2019).

References

Berwick, R. C., A. D. Friederici, N. Chomsky, and J. J. Bolhuis. 2013. Evolution, brain, and the nature of language. *Trends in Cognitive Sciences* 17 (2): 89–98. https://doi.org/10.1016/j.tics.2012.12.002.

Bolhuis, J. J., I. Tattersall, N. Chomsky, and R. C. Berwick. 2014. How could language have evolved? *PLoS Biology* 12 (8): e1001934. https://doi.org/10.1371/journal.pbio.1001934.

Brentari, D. 2010. *Sign Languages: A Cambridge Language Survey*. Cambridge, United Kingdom: Cambridge University Press.

Brentari, D., M. Coppola, L. Mazzoni, and S. Goldin-Meadow. 2012. When does a system become phonological? Handshape production in gesturers, signers, and homesigners. *Natural Language & Linguistic Theory* 30 (1): 1–31. https://doi.org/10.1007/s11049-011-9145-1.

Carrigan, E. M., and M. Coppola. 2017. Successful communication does not drive language development: Evidence from adult homesign. *Cognition* 158: 10–27. https://doi.org/10.1007/s11049-011-9145-1.

Cecchetto, C., C. Geraci, and S. Zucchi. 2009. Another way to mark syntactic dependencies: The case for right-peripheral specifiers in sign languages. *Language* 85 (2): 278–320. https://doi.org/10.1353/lan.0.0114.

Chen Pichler, D. 2012. Acquisition. In *Sign Language: An International Handbook*, edited by R. Pfau, M. Steinback, and B. Woll, 647–86. Boston: de Gruyter Mouton.

Chen Pichler, D., M. Kuntze, D. Lillo-Martin, R. M. de Quadros, and M. R. Stumpf. 2018. *Sign Language Acquisition by Deaf and Hearing Children: A Bilingual Introduction*. Washington, DC: Gallaudet University Press.

Chomsky, N. 1965. *Aspects of the Theory of Syntax*. Cambridge, MA: MIT Press.

Chomsky, N. 2011. Language and other cognitive systems. What is special about language?" *Language Learning and Development* 7 (4): 263–278. https://doi.org/10.1080/15475441.2011.584041.

Contreras, J., E. M. Carrigan, A. Shusterman, and M. Coppola. 2018. Language modality doesn't affect number concept development, but timing of language exposure does: Insights from deaf children acquiring signed and spoken language. Boston University Conference on Language Development. Boston, MA.

Coppola, M., and E. L. Newport. 2005. Grammatical subjects in home sign: Abstract linguistic structure in adult primary gesture systems without linguistic input. *Proceedings of the National Academy of Sciences* 102 (52): 19249–53. https://doi.org/10.1073/pnas.0509306102.

Crain, S. 1991. Language acquisition in the absence of experience. *Behavioral and Brain Sciences* 14: 597–650.

Curtiss, S. R. 1988. Abnormal language acquisition and the modularity of language. In *Linguistics: The Cambridge Survey: Volume 2, Linguistic Theory: Extensions and Implications*, edited by F. J. Newmeyer, 96–116. Cambridge, UK: Cambridge University Press.

Eastman, G. C. 1980. From student to professional: A personal chronicle of sign language. In *Sign Language and the Deaf Community: Essays in Honor of William C. Stokoe*, 9–34. Silver Spring, MD: National Association of the Deaf.

Fischer, S. D. 1974. Sign language and linguistic universals. In *Actes de Colloque Franco-Allemand de Grammaire Transformationelle. II. Etudes de Sémantique et Autres*, edited by T. Rohrer and N. Ruwet, 187–204. Tübingen: Niemeyer.

Fischer, S. D. 1975. Influences on word order change in American Sign Language. In *Word Order and Word Order Change*, edited by C. Li, 1–25. University of Texas Press.

Fischer, S. D. 1990. The head parameter in ASL. In *SLR '87: Papers from the Fourth International Symposium on Sign Language Research*, edited by W. H. Edmondson and F. Karlsson, 75–85. Hamburg, Germany: Signum.

Fischer, S. D. 2009. Sign language and linguistic universals. *Sign Language & Linguistics* 11 (2): 241–64. https://doi.org/10.1075/sll.11.2.05fis.

Fischer, S. D. 2017. Crosslinguistic variation in sign language syntax. *Annual Review of Linguistics* 3 (1): 125–47. https://doi.org/10.1146/annurev-linguistics-011516-034150.

Fischer, S. D., and B. Gough. 1978. Verbs in American Sign Language. *Sign Language Studies* 1018 (1): 17–48. https://doi.org/10.1353/sls.1978.0014.

Fodor, J. A. 1983. *The Modularity of Mind*. Cambridge: MIT Press.

Gale, E., P. A. de Villiers, J. G. de Villiers, and J. Pyers. 1996. Language and theory of mind in oral deaf children. In *Proceedings of the 20th Annual Boston University Conference on Language Development*, edited by A. Stringfellow, D. Cahana-Amitay, E. Hughes, and A. Zukowski, 213–24. Somerville, MA: Cascadilla Press.

Goldin-Meadow, S. 1982. The resilience of recursion: A study of a communication system developed without a conventional language model. In *Language Acquisition: The State of the Art*, edited by E. Wanner and L. Gleitman, 51–77. Cambridge, United Kingdom: Cambridge University Press.

Goldin-Meadow, S. 2003. *The Resilience of Language*. New York: Psychology Press.

Goldin-Meadow, S., and C. Mylander. 1998. Spontaneous sign systems created by deaf children in two cultures. *Nature* 391 (6664): 279–81. https://doi.org/10.1038/34646.

Hall, M. L., I.-M. Eigsti, H. Bortfeld, and D. Lillo-Martin. 2018. Executive function in deaf children: auditory access and language access. *Journal of Speech, Language, and Hearing Research* 61 (8): 1970–88. https://doi.org/10.1044/2018_JSLHR-L-17-0281.

Hall, M. L., W. C. Hall, and N. K. Caselli. 2019. Deaf children need language, not (just) speech. *First Language* 39 (4): 367–95. https://doi.org/10.1177/0142723719834102.

Hall, W. 2017. What you don't know can hurt you: The risk of language deprivation by impairing sign language development in deaf children. *Maternal and Child Health Journal* 21 (5): 961–965. https://doi.org/10.1007/s10995-017-2287-y.

Hauser, M. D, N. Chomsky, and W. T. Fitch. 2002. The faculty of language: What is it, who has it, and how did it evolve?" *Science* 298: 1569–1579.

Kegl, J. 1987. Coreference relations in American Sign Language. In *Studies in the Acquisition of Anaphora, edited by B. Lust, II: Applying the Constraints*: 135–170. Dordrecht: D. Reidel.

Kegl, J. 2003. Pronominalization in American Sign Language. *Sign Language & Linguistics* 6 (2): 245–65.

Kegl, J., A. Senghas, and M. Coppola. 1999. Creation through contact: Sign language emergence and sign language change in Nicaragua. In *Language Creation and Language Change: Creolization, Diachrony, and Development*, edited by M. DeGraff, 179–237. Cambridge, MA: MIT Press.

Kimmelman, V. 2017. Linearization of weak hand holds in Russian Sign Language. *Linguistics in Amsterdam* 10 (1): 28–59.

Kocab, A., A. Senghas, M. Coppola, and J. Snedeker. (under review). Recursive language emerges quickly when a new language community forms.

Koulidobrova, E., and D. Lillo-Martin. 2016. A "point" of inquiry: the case of the (non-) pronominal IX in ASL. In *The Impact of Pronominal Form on Interpretation*, edited by P. Grosz and P. Patel-Grosz, 221–250. Berlin: Mouton de Gruyter.

Landar, H. 1961. Review of "sign language structure: An outline of the visual communication systems of the American Deaf" by W.C. Stokoe. *Language* 37 (2): 269–71.

Liddell, S. K. 1980. *American Sign Language Syntax*. The Hague: Mouton.

Lillo-Martin, D. 1986. Two kinds of null arguments in American Sign Language. *Natural Language and Linguistic Theory* 4 (4): 415–444. https://doi.org/10.1007/BF00134469.

Lillo-Martin, D. 1991. *Universal Grammar and American Sign Language: Setting the Null Argument Parameters*. Dordrecht: Kluwer Academic Publishers.

Lillo-Martin, D. 1997. The modular effects of sign language acquisition. In *Relations of Language and Thought: The View from Sign Language and Deaf Children*, edited by M. Marschark, P. Siple, D. Lillo-Martin, R. Campbell, and V. S. Everhart, 62–109. New York: Oxford University Press.

Lillo-Martin, D. 2002. Where are all the modality effects?" In *Modality and Structure in Signed Language and Spoken Language*, edited by R. P. Meier, K. Cormier, and D. Quinto-Pozos, 241–62. Cambridge, UK: Cambridge University Press.

Lillo-Martin, D. 2016. Sign language acquisition studies. In *The Cambridge Handbook of Child Language, 2nd Edition*, edited by E. Bavin and L. R. Naigles, 504–526. Cambridge, UK: Cambridge University Press.

Lillo-Martin, D. 2018. The start of a revolution for deaf people's language. Commentary to accompany the reprinting of Stokoe's 1960 publication, "Sign Language Structure.'" *Society for ASL Journal* 2 (2): 7–10.

Lillo-Martin, D, and J. Gajewski. 2014. One grammar or two? Sign languages and the nature of human language: sign languages and the nature of human language. *Wiley Interdisciplinary Reviews: Cognitive Science* 5 (4): 387–401. https://doi.org/10.1002/wcs.1297.

Lillo-Martin, D., and E. S. Klima. 1990. Pointing out differences: ASL pronouns in syntactic theory. In *Theoretical Issues in Sign Language Research, Volume 1: Linguistics*, edited by S. D. Fischer and P. Siple, 191–210. Chicago: University of Chicago Press.

Lourenço, G., and R. B. Wilbur. 2018. Are plain verbs really plain?: Co-localization as the agreement marker in sign languages. *FEAST. Formal and Experimental Advances in Sign Language Theory* 2 (0): 68–81. https://doi.org/10.31009/FEAST.i2.06.

Mattingly, I. G., and M. Studdert-Kennedy, eds. 1991. *Modularity and the Motor Theory of Speech Perception*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Mayberry, R. I., and R. Kluender. 2018. Rethinking the critical period for language: New insights into an old question from American Sign Language. *Bilingualism: Language and Cognition* 21 (5): 886–905. https://doi.org/10.1017/S1366728917000724.

Meier, R. P., K. Cormier, and D. Quinto-Pozos. 2002. *Modality and Structure in Signed Language and Spoken Language*. Cambridge, United Kingdom: Cambridge University Press.

Mitchell, R. E., and M.A. Karchmer. 2004. Chasing the mythical ten percent: Parental hearing status of deaf and hard of hearing students in the United States. *Sign Language Studies* 4 (2): 138–163.

Morford, J. P., and S. K. Wood. 2016. Linguistics: Gestures and homesigns. In *The SAGE Deaf Studies Encyclopedia*, edited by G. Gertz and P. Boudreault, 611–613. Thousand Oaks, CA: SAGE Publications, Inc. https://doi.org/10.4135/9781483346489.n195.

Neidle, C., B. Bahan, D. MacLaughlin, R. G. Lee, and J. Kegl. 1998. Realizations of syntactic agreement in American Sign Language: Similarities between the Clause and the Noun Phrase. *Studia Linguistica* 52 (3): 191–226. https://doi.org/10.1111/1467-9582.00034.

Neidle, C., J. Kegl, D. MacLaughlin, B. Bahan, and R. G. Lee. 2000. *The Syntax of American Sign Language: Functional Categories and Hierarchical Structure*. Cambridge: MIT Press.

Nunes, J., and R. M. de Quadros. 2006. Duplication of WH-elements in Brazilian Sign Language. In *Proceedings of the 35th Annual Meeting of the North East Linguistic Society*, edited by L. Bateman and C. Ussery, 463–77. GLSA.

Padden, C. A. 1983. *Interaction of Morphology and Syntax in American Sign Language*. PhD Dissertation, University of California, San Diego.

Petronio, K., and D. Lillo-Martin. 1997. WH-movement and the position of Spec-CP: Evidence from American Sign Language. *Language* 73 (1): 18. https://doi.org/10.2307/416592.

Pfau, R., M. Salzmann, and M. Steinbach. 2018. The syntax of sign language agreement: common ingredients, but unusual recipe. *Glossa: A Journal of General Linguistics* 3 (1): 107. https://doi.org/10.5334/gjgl.511.

Pfau, R., M. Steinbach, and B. Woll, eds. 2012. *Sign Language – An International Handbook*. Berlin: Walter de Gruyter.

Pyers, J. E., and A. Senghas. 2009. Language promotes false-belief understanding: Evidence from learners of a Nicaraguan Sign Language. *Psychological Science* 20 (7): 805–812.

Quadros, R. M. de. 1999. *Phrase Structure of Brazilian Sign Language*. *PhD Dissertation*, Porto Alegre: PUC/RS.

Quer, J., C. Cecchetto, C. Donati, C. Geraci, M. Kelepir, R. Pfau, and M. Steinbach, eds. 2017. *SignGram Blueprint: A Guide to Sign Language Grammar Writing*. Berlin: de Gruyter Mouton.

Richie, R., C. Yang, and M. Coppola. 2014. Modeling the emergence of Lexicons in homesign systems. *Topics in Cognitive Science* 6 (1): 183–95. https://doi.org/10.1111/tops.12076.

Ross, J. R. 1967. *Constraints on Variables in Syntax*. PhD Dissertation, Massachusetts Institute of Technology.

Sandler, W. 1993. Sign language and modularity. *Lingua* 89 (4): 315–51.

Sandler, W., and D. Lillo-Martin. 2006. *Sign Language and Linguistic Universals*. New York: Cambridge University Press.

Schlenker, P. 2018. Visible meaning: Sign language and the foundations of semantics. *Theoretical Linguistics* 44 (3–4): 123–208. https://doi.org/10.1515/tl-2018-0012.

Senghas, A. 2003. Intergenerational influence and ontogenetic development in the emergence of spatial grammar in Nicaraguan Sign Language. *Cognitive Development* 18 (4): 511–531. https://doi.org/10.1016/j.cogdev.2003.09.006.

Shepard-Kegl, J. 1985. *Locative Relations in ASL Word Formation, Syntax and Discourse*. PhD dissertation, Massachusetts Institute of Technology.

Singleton, J. L., and E. L. Newport. 2004. When learners surpass their models: The acquisition of American Sign Language from inconsistent input. *Cognitive Psychology* 49 (4): 370–407.

Spaepen, E., M. Coppola, E. S. Spelke, S. E. Carey, and S. Goldin-Meadow. 2011. Number without a language model. *Proceedings of the National Academy of Sciences* 108 (8): 3163–68. https://doi.org/10.1073/pnas.1015975108.

Steinbach, M., and E. Onea. 2016. A DRT analysis of discourse referents and anaphora resolution in sign language. *Journal of Semantics* 33 (3): 409–48. https://doi.org/10.1093/jos/ffv002.

Stokoe, W. C. 1960. Sign language structure: An outline of the visual communication systems of the American deaf. *Studies in Linguistics* 8: 41.

Stokoe, W. C. 1990. An historical perspective on sign language research: A personal view. In *Sign Language Research: Theoretical Issues*, edited by C. Lucas, 1–8. Washington, DC: Gallaudet University Press.

Stokoe, W. C, D. Casterline, *and C.Croneberg*. 1965. *A Dictionary of American Sign Language on Linguistic Principles*. Washington D.C: Gallaudet College Press.

Tweney, R., and H. Hoemann. 1976. Translation and sign language. In *Translation: Applications and Research*, edited by R. Brislin, 138–61. New York: Gardner Press.

Wilbur, R. B. 1991. Intonation and focus in American sign language. In *ESCOL '90: Eastern States Conference on Linguistics*, edited by Y. No and M. Libucha, 320–331. Columbus: Ohio State University Press.

Wilbur, R. B. 1997. A prosodic/pragmatic explanation for word order variation in ASL with typological implications. In *Lexical and Syntactic Constructions and the Construction of Meaning*, edited by K. Lee, E. Sweetser, and M. Verspoor, 1:89–104. Philadelphia: John Benjamins.

Wilbur, R. B., and C. Patschke. 1999. Syntactic correlates of brow raise in ASL. *Sign Language & Linguistics* 2 (1): 3–41. https://doi.org/10.1075/sll.2.1.03wil.

23

Atypical Acquisition[1]

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23.1 Introduction

For more than 60 years, Chomsky has been an intellectual Colossus bestriding the worlds of language, philosophy, and the cognitive sciences, and focusing attention on the whole field and emphasizing the crucial importance of domains overlooked by the mainstream. One such area is the study of first-language acquisition, which has flourished under his inspiration, and has expanded from dealing with just everyday acquisition to cover a range of atypical examples. These provide evidence for an innate Universal Grammar (UG) and an introduction to Chomsky's work more generally.

We take "atypical acquisition" to cover two conceptually related situations: First, a variety of cases where there is an obvious "poverty of the stimulus" in that children either receive or perceive no linguistic input at the essential early stages referred to as critical periods; second, where there is rather the opposite situation: the case where the stimulus is rich, or at least plentiful and overt, but insufficient for or inaccessible to the learner's cognitive profile. Both forms of atypical acquisition have arisen out of Chomsky's seminal contribution to our understanding of language as a mental system, its development, architecture, and links with other aspects of human cognition. His review of Skinner's *Verbal Behavior* (Chomsky 1959) emphasized the importance of accounting for normal first language acquisition, and he has returned to it repeatedly in the ensuing 60 years: e.g. his 1965, 1975, 1986, 1995, 2002, etc. The first kind of atypical acquisition is exemplified by at least four subtypes:

- feral (so-called "wolf") children who are deprived of any language input;
- children who, because of their social isolation (e.g. under slavery) are exposed only to incomplete, "pidgin" languages;

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- deaf children of hearing parents;
- deaf-blind children whose dual disability means they cannot perceive signed or spoken language input.

The second kind of atypical acquisition, where language input is naturally available but the learner's genetic predisposition for language development is selectively impaired, is exemplified by at least three subtypes:

- children with Developmental Language Disorder (DLD; previously referred to as children with Specific Language Impairment (SLI)) who, despite being exposed to language input and natural interactions with parents and caretakers, are significantly delayed in their language development. Atypical language acquisition is a primary deficit for children with DLD;
- children with Autism Spectrum Disorders (ASD) whose atypical development is not primarily in formal language but in the area of (verbal) communication skills. For these children, language ability varies considerably, although for the majority, some language impairment is associated with their autism;
- the polyglot *savant* Christopher, whose awesome linguistic ability has not only enabled him to learn some 20 "second" languages, but extends to learning new languages. Yet the input his language gift thrives on is mostly written, while his use of oral and signed language is quite limited insofar as normal communication skills are concerned.

We discuss each of these in turn, but start by making explicit three key background assumptions: first, the necessity for a theory of language development covering neurotypical and atypical language acquisition; second, the fact that typical first-language acquisition takes place in a critical period or periods and third, that language or communication impairment can selectively reveal areas of language that are differentially sensitive to core, formal aspects of language or those relevant to the interface between formal and pragmatic uses of language.

23.2 Atypical Acquisition 1: Learners Deprived of Language Input

An irrefutable fact about language acquisition is that it can successfully take place only when sufficient and appropriate language input is available to the learner. What is more controversial is whether the time frame in which language acquisition takes place is appropriately described as a "critical period" (Lenneberg 1967; Chomsky 2013; Berwick et al. 2013).

The study of feral children, i.e. where children grow up in social isolation, provides a good example of input deprivation and its effects on language acquisition. The most well-studied case is that of Genie (Curtiss et al. 1974; Curtiss 1977), a girl who for some thirteen and a half years grew up in an isolation enforced by a mentally disturbed and tyrannical father. Once she was found and "liberated," she was given intensive exposure to language, with systematic testing over a number of months. Genie's language learning was very limited and proved to be particularly difficult in both the production and comprehension of complex syntax, even after seven years of intensive training. Specific areas of difficulty included spatial prepositions and sentences with

non-canonical mapping between argument structure and syntactic positions, such as passives. Genie's case provides strong support for the critical period hypothesis, even though the cognitive and emotional stress caused by her years of confinement may confound the strongest claims of critical period effects on language acquisition alone.

The second case of input deprivation can be found in children, also in enforced social isolation, who are exposed to input from pidgin or incomplete languages. The clearest case is provided by pidgin sign languages and their conversion into creoles reported in Kegl (2002); Senghas (1995); Chomsky (2013) and Berwick et al. (2013).

As far as first-language acquisition is concerned, being born deaf may be irrelevant or it may be devastating. For deaf children born to deaf parents and brought up in an environment where signing is as natural as speaking is in a hearing community, deafness is no bar to acquiring a natural human language; it is irrelevant.[2] By contrast, deaf children born to hearing parents and brought up in an environment where there is only spoken language may end up without a viable language at all – with characteristically devastating results.

Chomsky's observation about the case of Nicaraguan Sign Language, a language that developed in a community of children who had no other first language (spoken or signed), illustrates the significance of the innate human language endowment, UG:

> [T]he Nicaraguan case appears to be a very rich example, the richest yet known, of a natural experiment in which a language-like system, maybe an actual human language, was developed on the basis of no external input as far as we know and that's intriguing. (Chomsky 1996)

Lack of language input can nevertheless also be found in environments of social inclusion where emotional and social factors are expected and supportive. Our third case is provided by Deaf children of hearing parents. The vast majority of deaf children – about 95% – are born to hearing parents (Mitchell and Karchmer 2004). In this case, a loving and socially healthy environment still fails to provide linguistic input to the developing language learner (Mayberry 1994) who is at risk of emerging from childhood language-less. Fortunately, the technology surrounding cochlear implants is sufficiently sophisticated for it to be possible now to fit them to hearing-impaired children at less than 12 months (Lillo-Martin and Henner 2020: 103). Yet even "for those who received their implants before 18 months of age, three years later, the mean of their expressive and receptive language scores was equivalent to hearing children two years younger" (ibid p. 103). Why should this be so?

Lillo-Martin and Henner (2020) provide an overview of research into the role of age in the acquisition of signed and spoken languages by children with cochlear implants. Crucial evidence comes from cases of sign language acquisition by deaf children of hearing parents with different ages of onset to sign language exposure (Berk and Lillo-Martin 2012; Morford 2003; Ferjan Ramirez et al. 2013). This evidence provides overwhelming support for critical period effects. Even after sustained and lengthy exposure, aspects of complex syntax and morphology were particularly vulnerable in those learners who failed to achieve native levels of language ability.

Further, in a sophisticated study, Rachel Mayberry (1994) showed the crucial importance of very early exposure to linguistic input from either signed or spoken language. She demonstrated that "subjects who acquired American Sign Language as a second language after childhood outperformed those who acquired it as a first language at exactly the same age." That is, acquiring a first language, either spoken or signed, within

the critical period gives you an immediate advantage in acquiring another language, even if that language is not in the modality that would be optimal for the learner.[3]

Is being born blind comparably mixed in its effects? At first sight it might appear that blind children simply could not acquire those parts of a spoken language that encode properties of the visual world: verbs of visual perception and color terms, for instance. In pioneering work from the 1980s, Barbara Landau and Lila Gleitman (1985; see also Gleitman and Landau 2013; Gleitman, Chapter 7 of this volume) demonstrated that this common-sense assumption was not true and that blind children could successfully distinguish not only verbs like *look* and *see*, but also color terms initially thought to be beyond them.

Gleitman and Landau (2013, p. 99) in discussing these children's development of one, two, and three place predicates (e.g. *crying, tapping, giving*) observe that "the same fundamental relationships between verb meaning and nominal arguments surface in much the same way, and at the same developmental times, in the speech of children who are acquiring a conventional language, and in the gestures of linguistically isolated children who must invent one for themselves.

So blindness on its own is not the barrier to successful language acquisition that one might have expected. What about the deaf-blind? Here it is essential to be specific about when the two deficits originated (Capek et al. in preparation). People with type I Usher syndrome are born profoundly deaf and begin to go blind in the first decade of life; those with types II and III are characteristically hard of hearing rather than (profoundly) deaf at birth. It follows that all three types have the same potential ability to acquire native ability in sign language as other deaf people.

This leaves us with the fourth case of input deprivation: deaf-blind children who are unable to perceive signed or spoken language input. Sadly, this dual deficit constitutes an absolute block to normal first-language acquisition (Vervloed and Damen 2015). Despite this barrier, there are some cases of deaf-blind subjects with impressive linguistic abilities. The best known of these involve tactile communication and include Helen Keller and post-meningitis cases using Tadoma (Carol Chomsky 1986; Smith 1996). Tadoma is a method of teaching speech and speech-reading based solely on vibrotactile information. By putting his or her hand on the face and neck of the speaker, a trained deaf-blind person can monitor the articulatory motions associated with normal speech production. This provides information about laryngeal vibration (relevant for voicing distinctions), air-flow (relevant for distinctions of manner and place), lip movement (relevant for contrasts of roundedness), and jaw movements (relevant for some vowel distinctions). This is so much information that an experienced Tadoma user can interpret speech at a rate – and over a range – that approximates normality, and can do so with speakers who are entirely untrained. Carol Chomsky's inspirational article describes the case of three people who were left deaf and blind as a result of spinal meningitis at the ages of 19 months, 20 months, and 7 years, but who nonetheless developed a system of language and communication that put them within normal limits on a wide range of linguistic tests. These included the discrimination of minimal sets such as "hid, heed, had, hod, head"; disambiguation, identification of semantic anomaly, and so on.

It is important to emphasize that all the people Carol Chomsky tested had acquired basic linguistic ability *before* they went deaf-blind. There is little consensus on the actual age at which the critical period(s) for language acquisition is or are operative, but these examples show that it must predate 19 months. In phonology, there is evidence that

many aspects of infants' sensitivity to prosodic and allophonic contrasts are established between two and six months (Jusczyk 1997).

The Tadoma studies strikingly illustrate the poverty of the input stimulus and the corresponding importance of the "innate" component, but they simultaneously highlight the importance of exposure to language in the critical period.

23.3 Atypical Acquisition 2: Learners with Neuro Atypical Profiles

In this section we present atypicality in language acquisition that stems from the learner's atypical neurological profile rather than environmental or input properties. We will focus on Developmental Language Disorder (DLD), Autism Spectrum Disorder (ASD) and the case of the polyglot-savant Christopher to exemplify atypical acquisition.

DLD, also known as Specific Language Impairment, refers to children who display markedly impaired spoken language performance with test scores at least 1.25 SDs below the mean, despite normal nonverbal intelligence, and with no apparent sensory or neurological dysfunction (American Psychiatric Association 2000; World Health Organization 2013). Studies (Conti-Ramsden, Crutchley, and Botting 1997; Rapin and Dunn 2003) utilizing cluster analyses yield a larger set of subtly differentiated subtypes of DLD, with the most prominent being the one characterized by structural language impairments. Deficits in phonology and syntax are more severe than deficits in lexical aspects of language processing (Leonard 2000). Tense-marking errors (Bishop 2014; Rice and Wexler 1996) and the production of determiner elements (i.e. definite and indefinite determiners), and object clitics in languages with a full D system (Blom, Vasić, and Baker 2015; Chondrogianni and Marinis 2015; Tsimpli and Mastropavlou 2007; Tsimpli, Peristeri, and Andreou 2013) have been hallmarks of DLD. Furthermore, narrative studies converge to show high correlations between language measures such as word and sentence formation or sentence repetition, and microstructural measures, especially syntactic complexity, in the narrative production of children with DLD (Blom and Boerma 2016; Kuijper, Hartman, and Hendriks 2015; Tsimpli, Peristeri, and Andreou 2016).

Though children with DLD have been extensively shown to be impaired relative to their typically-developing (TD) peers on morphosyntactic measures, pragmatics does not seem to be completely unaffected, as reflected in a consistent pattern of deficits on relevant measures such as erroneous or irrelevant information or ambiguous use of reference (Norbury et al. 2004, 2014; Peristeri, Tsimpli and Andreou 2017). Bishop and Norbury (2005) derived a composite pragmatic language score and found a large correlation between this score and DLD children's ability to fluently generate novel ideas, even when their structural language and age were controlled for. Furthermore, DLD children's reference-shifting ability in a narrative production task (Peristeri et al. 2017) was found to be related to their performance in a mentalizing task that required children to take the perspective of another individual. Moreover, in a recent narrative comprehension study (Peristeri et al. in press) children with DLD were found to score lower than TD children in questions targeting the internal states of the story characters as well as in those requiring inference, even when participants' productive vocabulary and sentence repetition scores were taken as control variables. The specific findings suggest that formal language and pragmatics in DLD are not entirely separable, and that DLD, like autism, is a highly heterogeneous disorder, with different aspects of language being more

or less affected across individuals. Nevertheless, the morphosyntactic domain appears to be the primary deficit in DLD as shown in Arosio et al.'s (2017) study on Italian children with SLI. Focusing on compositional semantics and derived pragmatic meanings, the study shows spared abilities in these areas of language compared to morphosyntax.

Turning to a primary communication deficit, a diagnosis of Autism Spectrum Disorder (ASD) includes a specification of any co-occurrence of language deficits (American Psychiatric Association 2013; Van der Paelt et al. 2014), especially impairments in expressive language relative to receptive language (Grossman and Tager-Flusberg 2012). Studies on verbal children with ASD have reported that approximately 50% manifest significant structural language impairment, while the rest display normal abilities (Leyfer et al. 2008). Language abilities have typically been assessed via vocabulary tasks, which probably overestimate verbal abilities in this population, as vocabulary forms may be acquired as labels rather than full lexical representations (Mottron 2004). Though young children with ASD show typical semantic processing (Ellis Weismer et al. 2016; Rescorla and Sayfer 2013), lexical semantics has been found to be an area of weakness later in childhood (Ellawadi and McGregor 2016; Norbury et al. 2010). In contrast to typically-developing children for whom vocabulary development hinges upon the contents of their lexicon, children with ASD exhibit less contextual scaffolding and preferentially acquire words not semantically related to known words (Abdel-Aziz et al. 2018). In the same vein, studies offer converging evidence that lexical learning may develop distinctly in children with ASD relative to age-matched TD children due to the different organization of their lexicon or irregularities in domain-general associative learning principles that predict word learning patterns in TD children, or both (Potrzeba, Fein, and Naigles 2015; Tek, Jaffery, Fein and Naigles 2008).

In spite of a high degree of heterogeneity, syntactic impairment has often been observed in ASD and across a variety of categories. ASD children's productions often reveal omitted morphemes, wrong tense marking, and sparse use of questions (Eigsti, Bennetto, and Dadlani 2007; Modyanova, Perovic, and Wexler 2017; Roberts, Rice, and Tager-Flusberg 2004). In contrast, their comprehension data generally indicate intact, if somewhat delayed, grammatical understanding. Narrative studies with children with ASD reveal that many of the lower-level features typically used to characterize the *microstructure* of children's narrative production, such as syntactic complexity, narrative length, and diversity in the use of subordinate clauses are negatively affected in autism (Peristeri, Andreou, and Tsimpli 2017; Israelsen and Gillam 2016; Suh et al. 2014). Reduced narrative coherence and limited use of causal links between story events and emotion words to express characters' thoughts and intentions, particularly during unstructured narrative contexts, have also been found (Losh and Capps 2003; Norbury, Gemmel, and Paul 2014).

Besides the limitations on vocabulary and morphosyntax, researchers generally agree that pragmatic language impairment is universally observed in ASD (e.g. Ellis Weismer et al. 2011; Geurts and Embrechts 2008; Naigles and Chin 2015; Tager-Flusberg 1990). In fact, it has been claimed that deficits in grammatical development in children with ASD are *driven* by impaired pragmatic abilities. For instance, deficits in the description of past events may reflect ASD children's special difficulties in expressing past events for pragmatic rather than morphosyntactic reasons, e.g. with referencing non-present people or events (Eigsti et al. 2007; Jyotishi et al. 2017). Highly verbal ASD children's struggling with the production of pronominal clitics (e.g. *lo* in Spanish *lo vi* – him-saw.1s) and noun phrases in focus-sentences have been claimed to

reflect difficulties with identifying discourse prominent entities and stress, intonation and phrasing distinctions, respectively, rather than core grammar deficits (Terzi, Marinis, and Francis 2016; Shriberg et al. 2001). In the same vein, ASD children's frequently observed difficulty in comprehending and responding to *wh*-questions has been attributed to a difficulty in comprehending the pragmatics of these questions rather than to overall language delays (Goodwin, Fein, and Naigles 2012; Doggett et al. 2013; Secan, Egel, and Tiley 1989).

On the other hand, a deficit in pragmatics does not necessarily include every aspect of pragmatic processing. In Hochstein, Bale, and Barner's (2018) study, adolescents with ASD were found not to differ from neurotypical controls in using epistemic reasoning to compute scalar implicatures when explicitly asked to do so but not spontaneously, indicating that considering the mental states of others may not be a core component of scalar implicatures. In Hochstein et al.'s study, when adolescents with ASD were directly asked what a speaker knew or did not know, they showed awareness of speakers' mental states. However, when computing scalar implicatures of the type "Some/All boxes contain strawberries," individuals with ASD failed to spontaneously consider speakers' specific epistemic states (i.e. whether speakers had full or partial knowledge of the content of all boxes). Similarly, Chevallier et al. (2010) demonstrate that individuals with ASD achieve the pragmatic enrichment of *or* to the exclusive meaning to the same degree as the non-ASD control group. Such findings suggest that a universal pragmatic impairment in individuals with ASD needs to be qualified further for those pragmatic domains that presuppose theory of mind reasoning skills.

In all, although both DLD and ASD exhibit deficits in formal language and in pragmatics, the source of the attested deficits is asymmetrical: Formal language is the primary locus of impairment in DLD, while in ASD the primary locus is pragmatics. Thus, the theoretical distinction between narrow syntax and interfaces (Chomsky 1995, 2001), particularly those relevant to higher level of verbal cognition, such as syntax-discourse/pragmatics, continues to be supported by the evidence from these populations of atypical learners. Nevertheless, the permeability of language and communication deficits is strongly evinced by the coexistence of impairments in many levels of linguistic analysis in these clinical groups.

The final case of atypical acquisition is that of Christopher, a polyglot-*savant* whose unique cognitive and linguistic profile provides strong evidence for the dissociation of language, as a computational system, from verbal communication skills.

As a prelude, we should note that Christopher's unique talent in language is at odds with most other cases of *savantism*. Savants are individuals with a strongly asymmetrical cognitive profile: Their verbal and nonverbal abilities are at or below the lower end of the average scale while their communication skills are severely deficient. At the same time, savants excel in some special skill such as music, mental arithmetic and calendrical calculations, drawing, or sketching (Hermelin 2002). Howlin et al. (2009) report that savants are more frequently found in individuals with autism spectrum conditions than in any other group. Moreover, the majority of savants reported in the literature are autistic. But what is the link between "talent" and autism?

Baron-Cohen et al. (2009) suggest that excellent attention to detail, a characteristic of individuals with ASD that is independent of whether they are high- or low-functioning, is an indicator of *strong systemizing*. Systemizing is a higher cognitive ability which helps to extract patterns, rules, and generalizations from perceptual input. Autistic individuals are particularly good at extracting repeated patterns in stimuli,

while strong systemizing is also evident in their verbal and nonverbal behaviour. Savants exhibit an extreme version of the strong systemizing that is commonly found in autistic individuals: sensory hypersensitivity, hyper-attention to detail, and hyper-systemizing. Sensory hypersensitivity, i.e. sensitivity to low-level perceptual stimuli, seems to be enhanced in savants. Hyper-attention to detail allows savants to detect pieces in large patterns (e.g. Rubik's Cube) and also entertain "if *p* then *q*" type reasoning to solve the puzzle. Finally, hyper-systemizing as a basic inferential skill can lead to a high level of sophisticated knowledge of a perceptually accessible complex system. This needs to be supported by a memory system dedicated to the domain of hyper-systemizing of a particular savant. The memory system can then lead to the build-up, storage, and retrieval of complex, domain-specific knowledge. Baron-Cohen et al.'s (2009) proposal is consistent with Ericsson and Kintsch's (1995) postulation of a long-term working memory for experts in a specific field, such as professional chess players; long-term working memory is an ability that "requires a large body of relevant knowledge and patterns for the particular type of information involved" (Ericsson and Kintsch 1995, p. 215). Hyper-systemizing could be viewed as the development of a trait in typical individuals with high expertise in a particular domain. Music, arithmetic, and fine arts (drawing, sculpture) are highly complex systems in which savants in the literature excel. But language has not been a talent commonly found in savants, Christopher being an exceptional case.

As Chomsky has stressed from the start (Chomsky 1955/75), the complexity of human language is primarily based on recursion and discrete infinity, two properties that are attributed to much music and mathematics as well (Berwick and Chomsky 2011, 2016).[4] However, language is also the primary vehicle of thought in human cognition and the best system of communication that humans possess. As autism typically involves a deficit in social interaction and communication, but also a deficit in thought processes, language is not expected to be a domain of hyper-systemizing in savants (cf. Howlin et al. 2009). The uniqueness of Christopher's case is therefore a challenge if language ability is not understood as distinct from communication skills (Smith and Tsimpli 1995; Smith et al. 2011, and references therein).

Christopher's atypical acquisition is best exemplified by two aspects of his linguistic performance: dissociations within his native language (English) and his inability to learn "wild" grammars, i.e. grammars that violate universal principles of language design, UG (Smith, Tsimpli, and Ouhalla 1993).

Christopher speaks English as his native language. He understands, speaks, and judges English sentences of varied lexical and syntactic complexity as expected of a native speaker of the language. Long-distance *wh*-questions, island conditions (e.g. "*Who did John wonder when Mary met?)," sequence-of-tense phenomena (e.g. "Mary said she was/*is pregnant"), morphosyntactic agreement patterns, negative inversion, and other "core" phenomena of English grammar are within his native ability. In contrast, Christopher judges discourse-relevant structures such as topicalization (e.g. "John, I like") and dislocation (e.g. "John, I like him") as ungrammatical, fails to understand rhetorical questions and the use-mention distinction exemplified in "Dogs have four legs" vs. "'Dogs' has four letters." He also fails to recover from temporary structural ambiguity in garden-path structures. This asymmetry between his language skills appears to partly profile Christopher's language talent and communication deficit in a telling way. Christopher's inability to interpret irony and metaphor, metalinguistic negation, and figurative language in general fit his quasi-autistic profile in a similar way.

Christopher's atypical acquisition is further documented through his attempt to learn an artificial language, Epun, which included both structure-dependent and structure-independent operations. Christopher and a group of linguistics undergraduates were presented with the same Epun input (Smith et al. 1993; Smith and Tsimpli 1995). The structure-independent operations involved linear rules and word counting, banned in any natural language, e.g. to identify which position the emphatic particle should appear in a sentence to bring emphatic meaning to the inflected verb. The rule was that the emphatic particle had to appear suffixed to the third orthographic word of the sentence of which it was part. Christopher and the controls were unable to figure out this "impossible" rule, illustrating that within a language-learning environment even intelligent undergraduates were unable to consider simple puzzle-solving strategies. In contrast, other impossible but structure-dependent rules of Epun, such as the formation of negative sentences with a word-order change alone and no negative morpheme, proved to be learnable by the controls but not by Christopher, indicating that his second-language learning skills are triggered by lexical and morphological information that showcases patterns of a certain regularity in most of the languages he knows. The controls' learning success in this structure indicates that simple associations between meaning and form (word-order change in this case) are possible to learn within a structure-independent context using general problem-solving strategies.

Christopher's atypical acquisition strongly suggests that the complexity of language structure is learnable without a supporting, communicative and discourse-sensitive context. Syntax, morphology, the lexicon, and syntactic dependencies can be acquired within a learning scaffold that retains a certain autonomy and domain-specificity in cognitive architecture. Christopher's unusual – but deficient – working memory, his autistic traits, and his savantism allow us to document a case of atypical language learning where nonverbal cognition is severely challenged, motor, visuo-spatial, communicative, and learning skills are also poor, and language alone is spared.

23.4 Conclusions

Language acquisition can be atypical due to unavailable, reduced, or inaccessible input or because of the learner's genetic profile primarily affecting language and/or communication abilities. We presented four cases exemplifying limited input caused by social isolation or by inaccessible input in the case of deaf or deaf and blind children, focusing on critical period questions and the modality of the input presented to the learner in cases of social inclusion. We then outlined the language and communication skills of children with DLD and individuals with ASD, concluding with a brief presentation of Christopher's case, a striking example of a polyglot with very little interest in verbal or nonverbal communication. For Christopher, translation was largely a "non-communicative enterprise" (Smith and Tsimpli 1995:188), which typically resulted in his giving inappropriate translations even when he knew the correct form. For instance, despite giving a correct answer to the question whether he knew the difference between *savoir* and *connaître* in French, he failed to make the distinction in translating them, as seen in his rendering of *I know the man is going home* – Je sais que l'homme va chez lui – and *I know the man who is going home* – Je sais l'homme qui s'en ira chez lui. That is, his translation "stops short at the word-recognition stage" (Smith and Tsimpli 1995, p. 163) and fails to progress to a stage where communication is relevant.

Although the respective contributions of the quality and quantity of input on the one hand, and the learner's cognitive profile on the other, are hard to define in precise detail, extreme outcomes of atypical acquisition are found most strikingly in input deprivation where critical period effects are relevant and clear. These findings support Chomsky's view of language as an innately specified system biologically programmed to function optimally within a specific period of time. In contrast, where input is naturally available but the learner is atypical in terms of a primary deficit in language and/or communication skills, acquisition reveals asymmetries within language domains or in the interface between language and communication. These cases of atypical acquisition support Chomsky's idea that I-language is a distinct, genetically determined, computational system of the mind. Both ways of investigating atypical acquisition offer invaluable evidence for our understanding of language as a cognitive system and its interaction with other aspects of human cognition.

Endnotes

1 We are grateful to the editors for perceptive comments on an earlier version of this contribution.
2 Such signers will, of course experience difficulty with spoken language, just as speakers of one spoken language will have difficulty with any other.
3 This is not to deny the importance of Kegl's (2002) work showing that "first-language learners exposed to non-optimal input are able to reconstruct the grammar of ASL from sublexical morphological regularities within signs that have been learned as frozen wholes by their parents" (Kegl 2002: 211). But importantly these learners did not acquire near native-like proficiency in ASL.
4 See also Chomsky 1980, 52, and references cited there, including Hindemith 1952.

References

Abdel-Aziz, A., Kover, S. T., Wagner, M., Fein, D., and L. R. Naigles. 2018. The shape bias in children with autism spectrum disorder: Potential sources of individual differences. *Journal of Speech, Language, and Hearing Research*, 61: 2685–2702.

American Psychiatric Association. 2000. *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., text rev.). Washington, DC: Author.

American Psychiatric Association. 2013. *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.). Arlington, VA: Author.

Arosio, F., Foppolo, F., Pagliarini, E., Perugini, M., and M. T. Guasti. 2017. Semantic and pragmatic abilities can be spared in Italian children with SLI. *Language Learning and Development*, 13: 418–429, DOI: 10.1080/15475441.2017.1308254

Baron-Cohen, S. 2008. Autism, hyper-systemizing and truth. *Quarterly Journal of Experimental Psychology*, 61: 64–75.

Baron-Cohen, S., Ashwin, E., Ashwin, D., Tavassoli, T., and B. Chakrabarti. 2009. Talent in autism: Hyper-systemizing, hyper-attention to detail and sensory hypersensitivity. *Philosophical Transactions of the Royal Society B*, 364: 1377–1383.

Berwick, R., and N. Chomsky. 2011. Biolinguistics: The current state of its evolution and development. In *Biolinguistic Investigations*, edited by A. M. Di Sciullo, and C. Boeckx, 19– 41. Oxford, England: Oxford University Press.

Berwick, R. and N. Chomsky. 2016. *Why Only Us: Language and Evolution*. Cambridge, MA: MIT Press.

Berwick, R., Chomsky, N., and M. Piattelli-Palmarini. 2013. Poverty of the stimulus stands: Why recent challenges fail. In *Rich Languages from Poor Inputs*, edited by M. Piattelli-Palmarini, and R. Berwick, 19–42. Oxford, Oxford University Press.

Bishop, D. V. M. 2014. Ten questions about terminology for children with unexplained language problems. *International Journal of Language & Communication Disorders*, 49: 381–415.

Bishop, D.V.M., and C. F. Norbury. 2005. Executive function in children with communication impairments, in relation to autistic symptomatology: Volume 1: Generativity. *Autism*, 9: 7–27.

Blom, E., and T. Boerma. 2016. Why do children with language impairment have difficulties with narrative macrostructure? *Research in Developmental Disabilities*, 55: 301–311.

Blom, E., Vasić, N., and A., Baker. 2015. The pragmatics of articles in Dutch children with specific language impairment. *Lingua*, 155: 29–42.

Capek, C. M., Campbell, R., Gazarian, K., MacSweeney, M., Brammer, M., McGuire, P., David, A., and B. Woll. In prep. The neural organisation of visual and tactile language processing in Deaf adults with Usher syndrome: Functional plasticity in relation to experience and sensory loss.

Chevallier, C., Wilson, D., Happé, F., and I. Noveck. 2010. Scalar inferences in Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders*, 40: 1104–1117. DOI:10.1007/s10803-010-0960-8

Chomsky, C. 1986. Analytic study of the Tadoma method: language abilities of three deaf-blind subjects. *Journal of Speech and Hearing Research* 29: 332–347. Reprinted in *Rich Languages from Poor Inputs*, edited by M., Piattelli-Palmarini, and R. Berwick, 241–270. Oxford, Oxford University Press.

Chomsky, N. 1955/75. *The Logical Structure of Linguistic Theory*. Chicago: Chicago University Press.

Chomsky, N. 1959. Review of Skinner's *Verbal Behavior.Language*, 35: 26–58.

Chomsky, N. 1965. *Aspects of the Theory of Syntax*. MIT Press.

Chomsky, N. 1975. *Reflections on Language*. New York: Pantheon Books.

Chomsky, N. 1980. Rules and representations. *Behavioral and Brain Sciences* 3 (01): 1–15; 42–61.

Chomsky, N. 1986. *Knowledge of Language: Its Nature, Origin, and Use*. New York: Praeger.

Chomsky, N. 1995. *The Minimalist Program*. Cambridge, Mass.: MIT Press.

Chomsky, N. 1996. Silent children, new language: Noam Chomsky interviewed by an anonymous BBC interviewer. Available at https://chomsky.info/1996____/

Chomsky, N. 2001. Derivation by phrase. In *Ken Hale: A Life in Language*, edited by M. Kenstowicz, 1–52. Cambridge, MA: MIT Press.

Chomsky, N. 2002. *On Nature and Language*. Cambridge: Cambridge University Press.

Chomsky, N. 2013. Poverty of the stimulus: Willingness to be puzzled. In *Rich Languages from Poor Inputs*, edited by M. Piattelli-Palmarini, and R. Berwick (eds.), 61–67. Oxford: Oxford University Press.

Chondrogianni, V., and T. Marinis. 2015. Production of definite and indefinite articles in typically developing English-speaking children and children with SLI. *Lingua*, 155: 9–28.

Conti-Ramsden, G., Crutchley, A., and N. Botting. 1997. The extent to which psychometric tests differentiate subgroups of children with SLI. *Journal of Speech, Language and Hearing Research*, 40: 765–777.

Curtiss, S. 1977. *Genie: A Psycholinguistic Study of a Modern day "Wild Child"*. New York: Academic Press.

Curtiss, S., Fromkin, V., Krashen, S., Rigler, D., and M. Rigler. 1974. The linguistic development of Genie. *Language*, 50: 528–554.

Doggett, R. A., Krasno, A. M., Koegel, L. K., and R. L. Koegel. 2013. Acquisition of multiple questions in the context of social conversation in children with autism. *Journal of Autism and Developmental Disorders*, 43: 2015–2025.

Eigsti, I. M., Bennetto, L., and M. B. Dadlani. 2007. Beyond pragmatics: Morphosyntactic development in autism. *Journal of Autism and Developmental Disorders*, 37: 1007–1023.

Ellawadi, A. B, and K. K. McGregor. 2016. Children with ASD can use gaze to map new words. *International Journal of Language & Communication Disorders*, 51: 212–218.

Ellis Weismer S., Gernsbacher M. A., Stronach S., Karasinski C., Eernisse E., Erickson C., and H. Sindberg 2011. Lexical and grammatical skills in toddlers on the autism spectrum compared to late talking toddlers. *Journal of Autism and Developmental Disorders*, 41: 1065–1075.

Ellis Weismer, S., Haebig, E., Edwards, J., Saffran, J., and C. E. Venker. 2016. Lexical processing in toddlers with ASD: Does weak central coherence play a role? *Journal of Autism and Developmental Disorders*, 46: 3755–3769.

Ericsson, K. A., and W. Kintsch. 1995. Long-term working memory. *Psychological Review*, 102: 211–245.

Ferjan Ramirez, N., Lieberman, A. M., and R. I. Mayberry. 2013. The initial stages of first-language acquisition begun in adolescence: when late looks early. *Journal of Child Language*, 40: 391–414.

Geurts, H. M., and M. Embrechts. 2008. Language profiles in ASD, SLI, and ADHD. *Journal of Autism and Developmental Disorders*, 38: 1931–1943.

Gleitman, L., and B. Landau. 2013. Every child an isolate: Nature's experiments in language learning. In *Rich Languages from Poor Inputs*, edited by M. Piattelli-Palmarini, and R. Berwick, 81–104. Oxford: Oxford University Press.

Goodwin, A., Fein, D., and L. Naigles. 2012. Comprehension of *wh*-questions precedes their production in typical development and autism spectrum disorders. *Autism Research*, 5: 109–123.

Grossman, R. B., and H. Tager-Flusberg. 2012. Quality matters! Differences between expressive and receptive non-verbal communication skills in adolescents with ASD. *Research in Autism Spectrum Disorders*, 6: 1150–1155.

Hermelin, B. 2002. *Bright Splinters of the Mind: A Personal Story of Research with Autistic Savants*. London: Jessica Kingsley.

Hindemith, P. 1952. *A Composer's World: Horizons and Limitations*. Cambridge: Harvard University Press.

Hochstein, L., Bale, A., and D. Barner. 2018. Scalar implicature in absence of epistemic reasoning? The case of autism spectrum disorder. *Language Learning & Development*, 14: 224–240.

Howlin, P., Goode, S., Hutton, J., and M. Rutter. 2009. Savant skills in autism: Psychometric approaches and parental reports. *Philosophical Transactions of the Royal Society of London B*, 364: 1359–1367.

Israelsen, M., and S. L. Gillam. 2016. The relationship between narrative proficiency and syntactic complexity of story retells elicited from children with ASD spectrum disorders (ASD). *Autism Open Access*, 6. DOI: 10.4172/2165-7890.1000181.

Jusczyk, P. W. 1997. *Language, Speech, and Communication. The Discovery of Spoken Language*. Cambridge, Mass.: MIT Press.

Jyotishi, M., Fein, D., and L. Naigles. 2017. Investigating the grammatical and pragmatic Origins of wh-questions in children with Autism Spectrum Disorders. *Frontiers in Psychology*, 8: 319.

Kegl, J. 2002. Language emergence in a language-ready brain: Acquisition. In *Directions in Sign Language Acquisition*, edited by G. Morgan, and B. Woll, 207–254. Amsterdam: John Benjamins.

Kuijper, S. J. M., Hartman, C. A., and P. Hendriks. 2015. Who is he? Children with ASD and ADHD take the listener into account in their production of ambiguous pronouns. *PLoS ONE*, 10: e0132408.

Landau, B., and L. Gleitman. 1985. *Language and Experience: Evidence from the Blind Child*. Cambridge, MA: Harvard University Press.

Lenneberg, E. 1967. *Biological Foundations of Language*. New York: Wiley.

Leonard, L. B. 2000. Specific language impairment across languages. In *Speech and Language Impairments in Children: Causes, Characteristics, Intervention and Outcome*, edited by D. V. M. Bishop and L. B. Leonard, 115–129. Hove, UK: Psychology Press.

Leyfer, O. T., Tager-Flusberg, H., Dowd, M., Tomblin, J. B., and S. E. Folstein. 2008. Overlap between autism and specific language impairment: comparison of autism diagnostic interview and autism diagnostic observation schedule scores. *Autism Research*, 1: 284–296.

Lillo-Martin, D., and J. Henner. 2020. Acquisition of sign languages. *Annual Review of Linguistics.* 7: 1.

Losh, M., and L. Capps. 2003. Narrative ability in high-functioning children with autism or Asperger's syndrome. *Journal of Autism and Developmental Disorders*, 33: 239–251.

Mayberry, R. 1994. First-language acquisition after childhood differs from second-language acquisition: the case of American Sign Language. *Journal of Speech and Hearing Research*, 36: 1258–1270.

Mitchell, R. E., and M. A. Karchmer. 2004. Chasing the mythical ten percent: Parental hearing status of deaf and hard of hearing students in the United States. *Sign Language Studies*, 4: 138–168.

Modyanova, N., Perovic, A., and K. Wexler. 2017. Is language impaired in subgroups of autism spectrum disorders? Evidence from an investigation of tense marking and morphosyntax. *Frontiers in Psychology (Special issue: Investigating Grammar in Autism Spectrum Disorders)*, 8: 1–23.

Morford, J. 2003. Grammatical development in adolescent first-language learners. *Linguistics.* 41: 681–721.

Mottron, L. 2004. Matching strategies in cognitive research with individuals with high-functioning autism: Current practices, instrument biases, and recommendations. *Journal of Autism and Developmental Disorders*, 34: 19–27.

Naigles, L. R., and I. Chin. 2015. Language development in children with autism. In *Cambridge Handbook of Child Language*, edited by E. Bavin, and L. Naigles L, 637–658. Cambridge: Cambridge University Press.

Norbury, C., Gemmell, T., and R. Paul. 2014. Pragmatic abilities in narrative production: A cross disorder comparison. *Journal of Child Language*, 41: 485–510.

Norbury, C. F., Griffiths, H., and K. Nation. 2010. Sound before meaning: Word learning in autistic disorders. *Neuropsychologia*, 48: 4012–4019.

Norbury, C.F., Nash, M., Baird, G., and D. V. M. Bishop. 2004. Using a parental checklist to identify diagnostic groups in children with communication disorder: A validation of the Children's Communication Checklist—2. *International Journal of Language & Communication Disorders*, 39: 345–364.

Peristeri, E., Andreou, M., and I. M. Tsimpli. 2017. Syntactic and story structure complexity in the narratives of high- and low-language ability children with autism spectrum disorder. *Frontiers in Psychology* (Special Issue: Investigating Grammar in Autism Spectrum Disorders), 8: 2027.

Peristeri, E., Andreou, M., Tsimpli, I. M., and S. Durrleman. in press. Bilingualism effects in the listening comprehension skills of children with Developmental Language Disorder: Associations with formal language, executive functions and Theory of Mind. In *Developing Narrative Comprehension: Multilingual Assessment Instrument for Narratives*, edited by U. Bohnacker, and N. Gagarina. John Benjamins Publishing Company.

Peristeri, E., Tsimpli, I. M., and M. Andreou. 2017. Object clitic production in monolingual and bilingual children with Specific Language Impairment: a comparison between elicited production and narratives. *Linguistic Approaches to Bilingualism*, 7: 394–430.

Potrzeba, E. R., Fein, D., and L. Naigles. 2015. Investigating the shape bias in typically developing children and children with autism spectrum disorders. *Frontiers in Psychology*, 6: 446.

Rapin, I., and M. Dunn. 2003. Update on the language disorders of individuals on the autistic spectrum. *Brain and Development*, 25: 166–172.

Rescorla, L., and P. Safyer. 2013. Lexical composition in children with autism spectrum disorder (ASD). *Journal of Child Language*, 40: 47–68.

Rice, M. L., and K. Wexler. 1996. Toward tense as a clinical marker of specific language impairment in English-speaking children. *Journal of Speech & Hearing Research*, 39: 1239–1257.

Roberts, J. A., Rice, M. L., and H. Tager-Flusberg. 2004. Tense marking in children with autism. *Applied Psycholinguistics*. 25: 429–448.

Secan, K. E., Egel, A. L., and C. S. Tilley. 1989. Acquisition, generalization, and maintenance of question-answering skills in autistic children. *Journal of Applied Behavior Analysis*, 22: 181–196.

Senghas, A. 1995. *Children's Contribution to the Birth of Nicaraguan Sign Language*. MIT PhD Thesis.

Shriberg, L., Paul, R., McSweeney, J., Klin, A., Cohen, D., and F. Volkmar. 2001. Speech and prosody characteristics of adolescents and adults with high functioning autism and Asperger syndrome. *Journal of Speech, Language and Hearing Research*, 44: 1097–1115.

Smith, N. 1996. Tadoma. *Glot International* 2 (3): 5.

Smith, N., and I. M. Tsimpli. 1995. *The Mind of a Savant: Language-learning and Modularity*. Oxford: Blackwell.

Smith, N., Tsimpli, I. M., Morgan, G., and B. Woll. 2011. *The Signs of a Savant: Language against the Odds*. Cambridge: Cambridge University Press.

Smith, N., Tsimpli, I. M., and J. Ouhalla. 1993. Learning the impossible: The acquisition of possible and impossible languages by a polyglot savant. *Lingua*, 91: 279–347.

Suh, J., Eigsti, I. M., Naigles, L., Barton, M., Kelley, E., and D. Fein. 2014. Narrative performance of optimal outcome children and adolescents with a history of an Autism Spectrum Disorder (ASD). *Journal of Autism and Developmental Disorders*, 44: 1681–1694.

Tager-Flusberg, H., Calkins, S., Nolin, T., Baumberger, T., Anderson, M., and A. Chadwick-Dias. 1990. A longitudinal study of language acquisition in autistic and Down syndrome children. *Journal of Autism and Developmental Disorders*, 20: 1–21.

Tek, S., Jaffery, G., Fein, D., and N. Naigles. 2008. Do children with autism spectrum disorders show a shape bias in word learning? *Autism Research*, 1: 208–222.

Terzi, A., Marinis, T., and K. Francis. 2016. The interface of syntax with pragmatics and prosody in children with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, 46: 2692–2706.

Tsimpli, I. M., and M. Mastropavlou. 2007. Feature interpretability in L2 acquisition and SLI: Greek clitics and determiners. In *The Role of Formal Features in Second Language Acquisition*, edited by J. Liceras, H. Zobl, and H. Goodluck, 143–169. Mahwah, NJ: Lawrence Erlbaum.

Tsimpli, I. M., Peristeri, E., and M. Andreou. 2013. A study of clitic pronoun production in monolingual and bilingual children with specific language impairment (in Greek). *Psixologia*, 20: 302–320.

Tsimpli, I. M., Peristeri, E., and M. Andreou. 2016. Narrative production in monolingual and bilingual children with Specific Language Impairment. *Applied Psycholinguistics*, 37: 195–216.

van der Paelt, S., Warreyn, P., and H. Roeyers. 2014. Social-communicative abilities and language in preschoolers with autism spectrum disorders: Associations differ depending on language age. *Research in Autism Spectrum Disorders*, 8: 518–528.

Vervloed, M., and S. Damen. 2015. Language and communication in people who are deafblind. In *The Oxford Handbook of Deaf Studies in Language*, edited by M. Marschark, and P. Spencer, 325–343. Oxford: Oxford University Press.

World Health Organization. 2013. *World Health Statistics*, 2013. Retrieved from http://www.who.int/gho/publications/world_health_statistics/2013/en/

Part V

Semantics, Pragmatics, and Philosophy of Language

24

Chomsky and the Analytical Tradition

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24.1 Introduction

Chomsky's engagement with contemporary philosophy from the 1960s onwards has involved lengthy discussion with critics and others on the significance of linguistics for traditional and contemporary philosophy. Too little has been made, however, of the growth of generative linguistics from the rich soil of the analytical tradition in philosophy, especially in its development of formal techniques and systems for the analysis of formal languages and their application to natural language. In this chapter, I shall briefly chart the background to generative linguistics and then show how Chomsky's real philosophical achievement in this area was to pose an explanatory question that had previously been neglected, if noticed at all. In this light, Chomsky belongs to the analytical tradition, but advances at a tangent from its received positions post-1950s.

24.2 Formal Beginnings

The nineteenth century witnessed a general formalization of mathematical practice and results, as well as reflection on the status of mathematics as a special discipline, distinct from empirical sciences with respect to the certainty of its results and the methods used. At its simplest, formalization means that mathematical reasoning is rendered so that both its primitive concepts and its permissible rules of inference do not depend on intuitive or perceptual notions. Thus, a mathematical proof should be explicit in the sense that it can be laid out and checked for validity in a mechanical fashion independent of any particular intuitions or experiences. Nineteenth century formalization reached its apogee in the work of Gotlob Frege, who in his (1879) developed a novel formalization of logic, what he called a *Begriffsschrift*, or "concept script." Frege endeavored to show that, given definitions of basic terms, such as those of *number* (natural, rational, real), *all of mathematics could be derived from logic*.[1]

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The logic in question that Frege developed departs from traditional Aristotelian logic in a number of significant respects. Roughly, the "new" logic dealt not only with Boolean combinations of sentences (*p or not q*, *p only if q*, etc.) and monadic predicates, such as "x is even" or "x is prime," expressing properties, but indefinitely many *polyadic* predicates, such as $x > y$, $x + y = z$, expressing *relations*, each variable of which may be bound by either a universal (∀) or existential (∃) quantifier, enabling the expression of such simple truths as $(\forall x)(\forall y)(\exists z)(x + y = z)$ (i.e. *Every pair of numbers has a sum*) which were inexpressible in earlier systems. Such a system can be extended, as was essential to Frege's aims, to involve quantification over predicates of any adicity.

Although Frege's principal concern was mathematics, the new logic had a wider linguistic and philosophical significance. The old logic closely tracked the basic grammatical distinction between subject and predicate, such that a sentence or judgment is true just in case whatever the subject refers to possesses the property the predicate expresses. In the new logic, there is not a general subject-predicate distinction. For example, in the sentence *Every whale is a mammal*, the subject *every whale* does not, for Frege, pick out an object, still less one that has the property of being a mammal. That conclusion is clearly correct, for only individual whales are mammals, not whalehood or the set of whales. Paraphrased into English, the new logic would render the sentence as

(1) Everything is such that if it is a whale, then it is a mammal;

or in modern notation:

(2) $(\forall x)[\mathrm{WHALE}(x) \rightarrow \mathrm{MAMMAL}(x)])$.

Russell (1905), pursuing Frege's basic insights, would famously render definite descriptions, such as in *The present king of France* (PKF) *is bald*, into quantifier notation, so that the sentence expresses a conjunction of three claims: there is at least one PKF, there is at most one, and he is bald. In modern notation:

(3) $(\exists \mathrm{x})[\mathrm{PKF}(x) \,\&\, (\forall y)[\mathrm{PKF}(y) \rightarrow x = y] \,\&\, \mathrm{BALD}(x)])$.

The hoped-for philosophical upshot was that long-standing philosophical puzzles could be resolved by the new logical techniques. Wittgenstein (1922) elevated this desideratum into a fundamental claim that any possible truth-apt representation in general, whether in thought, natural language, or scientific theories had to cleave to a basic underlying logical form that isomorphically mirrors or pictures the state of affairs it represents. Rudolf Carnap (1928, 1934) had the slightly more modest ambition to develop a general logic that covered all scientific truth-apt representations, but abjured any fundamentalist claims (see next section).

Carnap's methods of logical construction were pursued by Nelson Goodman in his (1951), *The Structure of Appearance*. It is this last work that is the bridge to Chomsky, who, on the advice of his teacher, the linguist Zellig Harris, encountered it a seminar Goodman was presenting at the University of Pennsylvania in 1946. Along with Harris's formal efforts in linguistics, the logical constructions of sensory experience that Goodman was meticulously providing served as something of a paradigm for Chomsky's first major work, *The Logical Structure of Linguistic Theory* (the manuscript was prepared in

1954–55, but not published until 1975). As we shall see, though, the "constructionist" aspect had been mostly ditched.

Parallel to these developments were inquiries into the power and limits of formal systems and how best to define both primitive mathematical concepts and meta-concepts that apply to formal systems, such as consistency, proof, consequence, definition, and truth. These inquiries held an especial importance due to the contradictions found in the mature system of Frege. Various surprising limitive results were achieved. In particular, Kurt Gödel (1931) and Alonzo Church (1936) proved, respectively, that the functions for generating truths of arithmetic and valid arguments for first-order logic were undecidable, and Turing (1936) provided a general conception of computability in terms of an idealized machine (a *Turing machine* with unbounded memory), which operated mechanically on formal symbols *and with access to an unbounded memory*. He proposed the *thesis* (not a theorem to be proved) that a function is computable if and only if there is a Turing machine that will compute it, offering thereby a general mathematical characterization of the class of computable functions, without appeal to any intuitive notions.

Chomsky also built on this work by variously restricting the kind of memory available to a system and the rules it may permit. This was to be foundational for mathematical linguistics and computer science (see Turner, this volume).

24.3 Chomsky and Formality

The theorists who developed the formal techniques previously discussed did not ask a basic question: What is the relation between a formal system and natural language? To be sure, there were many general admonitions to the effect that a formal system ought to replace natural language for scientific and mathematical purposes; a formal system is simply an invented language, along with rules for inference and interpretation that is designed purposefully to avoid the ambiguities, vagaries, and inconsistencies of natural language.

Although Russell (in some incarnations) and the early Wittgenstein seemed to regard their efforts at analyses as uncovering the deep "logical form" of our assertions about the world, Carnap (1934, Section 17), on the contrary, recommended an essentially pragmatic attitude:

> Principle of Tolerance: It is not our business to set up prohibitions, but to arrive at conclusions.

Carnap explains:

> In logic, there are no morals. Everyone is at liberty to build his own logic, i.e. his own form of language, as he wishes. All that is required of him is that, if he wishes to discuss it, he must state his methods clearly, and give syntactical rules instead of philosophical arguments.

For Carnap, theorists are free to develop formal systems of any kind unhindered by philosophical strictures. Their only obligation is to be explicit about the system, in terms of what formulae are recognized by the system and what rules of inference are available. Different systems may then be compared and assessed in terms of their general utility in applying to different discourses, particularly scientific and mathematical theories.

Yet none of that, of course, goes to answer the question of how a speaker can be properly said to articulate a meaning with a certain logical structure by way of uttering a sentence with a quite distinct structure. How do the natural and artificial systems relate to one another? Chomsky was perhaps the first person properly to raise this issue, and certainly the first to set about answering it. He treated the question as essentially a demand for an explanation of people's competence to speak a language.

In an early philosophical paper, Chomsky suggested that, while the development of a formal system will play a crucial methodological role for linguistics, the system itself ought not to be expected to offer a direct model for natural language:

> The correct way to use the insights and techniques of logic is in formulating a general theory of linguistic structure. But this fact does not tell us what sort of systems form the subject matter for linguistics … I do object to the thesis that incorporating logical syntax and semantics into linguistics will solve certain of its problems, or that the theory of meaning in natural language is in anyway clarified by constructing artificial languages in terms of rules which contain the word "synonymous." (Chomsky 1955, p. 45)

Although an early remark, Chomsky, as we shall see, has not reneged on it.

Generative grammar as a research field was initiated by Chomsky in the 1950s. In addition to Goodman, the direct influences on Chomsky's approach were Zelig Harris and W. V. Quine, along with purely technical influences from Emil Post and Alan Turing (see Chomsky 1954–55/75, p. 33). The initial idea was to develop a method of constructional systems a la Carnap, whereby a set of grammatical notions could be formally defined or constructed from a set of primitive elements that were empirically established in term of the behavior of the native speaker (Chomsky 1953). One could think of the ultimate ambition to be the development of a general linguistic theory (what was to be renamed Universal Grammar, UG), which would provide the primitive conceptual base and kind of rules that might have application to any language, where the construction of the class of grammatical sentences for a particular language would amount to its grammar in the technical sense intended. This approach echoed that of Harris (1951), at least for particular languages, and, more generally, the philosophical approach we've already mentioned of Carnap and Goodman. Much of the philosophical discussion of this approach centered on how one might formally measure the simplicity of a given construction. That is, the most simple construction should be favored, but is there a way of measuring simplicity free of mere intuition? A natural proposal was to measure lengths of derivation, a proposal dependent on a choice of rule system and notation. Chomsky was variously to adopt this basic idea in future work running up to his (1965) *Aspects of the Theory of Syntax*. Chomsky's general orientation toward construction was soon to change, however.

The central factor in this change was a demand for explanation of speakers' capacity to understand and produce indefinitely novel and complex natural language sentences. Both *The Logical Structure of Linguistic Theory* (1954–55/75) and *Syntactic Structures* (1957) gave absolute primacy to such explanatory goals. The general idea here is that a mere construction or definition of a set of applicable (grammatical) concepts is an appropriate goal for a formal science, but offers slim rewards, as Chomsky (1955) notes, if the aim is to explain why languages have the properties they have. The proper ambition here is not merely to "construct" the phenomena in a formally precise manner. Thus, a grammar must extend beyond mere extensional adequacy, which is met simply by a grammar including all and only grammatical strings, to a conception under

which an adequate grammar will assign definite structures to strings that will explain the sentences' properties, such as why a sentence type is ambiguous, whereas another is not, and why it is ambiguous in just two ways, say, not three (Chomsky 1954, p. 123).[2]

Likewise, we want an explanation of the relation between, say, active and passive, and declarative and interrogative. Concomitant to this general explanatory orientation was an abandonment of the notion that a grammar may or should be grounded in a primitive base of notions anchored to the behavior of speakers. Rather, a grammar trades in unobservables in terms of which laws and formal principles might be framed that capture the counterfactuals concerning how speakers will interpret and find (un)acceptable various linguistic inputs. It will, in other words, essentially go beyond whatever happens to be observable in the language. We see this move clearly in *Syntactic Structures* (Chomsky 1957, p. 33), where the empirical requirement for a grammar is to be at least as rich as phrase structure grammar, rather than a finite state machine, and this has the consequence that an adequate grammar will essentially trade in variables encoding grammatical categories, which cannot be reduced to any particular class of observable linguistic phenomena.

Once this direction toward explanation rather than merely extensionally adequate definition or construction is taken, a cognitive turn is natural, and so Chomsky went on to reject the similarly extensionalist behaviorism that then dominated psychology. This move is first explicit in his famous (1959) review of Skinner's *Verbal Behavior*, but was fully articulated in his (1965) *Aspects*. A grammar is conceived not to be a formal description of external behavior in the shape of a corpus, or the probability of use, but a formal model of what a speaker-hearer knows, for the properties of how the speaker-hearer represents her sentences explain why the phenomena are the way they are. A sentence, say, is not ambiguous because of its probability to be used with two or more meanings, still less its actually being used (it might never actually be used in certain ways, if at all!), but because speaker-hearers can construe it in various definite ways, but not others. In this sense, ambiguity reflects general principles of knowledge of language rather than accidental facts of usage. The explanatory task is thus to show how the speaker–hearer is peculiarly constrained to respect grammatical principles and rules. The principal cognitive question thus becomes one of how speaker–hearers can come to be so constrained, when the grammatical specification of the constraints fundamental concepts and principles are not reducible to or constructible from observable features. Such apparent poverty of stimulus thus poses a challenge that the innateness of the general shape of each acquirable grammar answers.

24.4 Objectivity, Analysis, and Explanation

Chomsky's cognitive turn was revolutionary, not least because it went against the philosophical grain vis-à-vis the role of formalism or logical analysis. Recall Carnap's evocation of tolerance, whereby there is no uniquely correct theory, but only more or less adequate analyses that meet whatever conditions are relevant to the inquiry at issue. Let us assume that Carnap is correct here: logic admits of plurality, there being no correct universal logic. It doesn't follow, of course, that the character of a formal language whose job is to capture and explain real phenomena should attract equal tolerance. That would be akin to thinking that any theory is equally sound so long as it proves useful in some relevant way. In particular, if we follow Chomsky in his

cognitive turn, then what a formal account of any aspect of language is seeking to capture, whether it be syntax, semantics, or phonology, is the underlying structures that constrain an agent's comprehension, consumption, and production of language, which is as much a natural fact as is our digestion. Still, something akin to Carnap's tolerance has been a dominant theme in thinking about the logical representation of natural language.

Quine (1960, 159), for example, has this to say:

> The artificial notation of logic is itself explained, of course, in ordinary language. The explanations amount to the implicit specification of simple mechanical operations whereby any sentence in logical notation can be directly expanded, if not into quite ordinary language, at least into semi-ordinary language … [T]o paraphrase a sentence of ordinary language into logical symbols is virtually to paraphrase it into a special part still of ordinary or semi-ordinary language; for the shapes of the individual characters are unimportant.

Thus, Russell's first-order logical analysis of definite descriptions, for example, allows one to be explicit about the scope ambiguities involving definite descriptions and negation. For Quine, though, the analysis is not objectively true, as a physical theory might be; it is intended merely to express a clear paraphrase of the target sentences. Quine, to be sure, was an adherent of first-order logic throughout his career, but this was because of its apparent simplicity and freedom from metaphysical quandaries over its interpretation. Quine reasons as if tolerance holds sway, but only one logic need be tolerated for science and philosophy to do their business. In particular, he rejected a certain kind of realism about the logical or formal analysis of natural language. Thus, in response to Chomsky, Quine (1972, p. 451) avers:

> I find the phrase "logical analysis" misleading, in its suggestion that we are exposing a logical structure that lay hidden in the sentence all along. This conception I find both obscure and idle. When we move from verbal sentences to logical formulas we are merely retreating to a notation that has certain technical advantages, algorithmic and conceptual … [D]eep structure loses its objectivity … [T]he grammarian's deep structure is similar in a way to logical structure. Both are paraphrases of sentences of ordinary language.[3]

Quine's point here is that just as a choice of logic is governed by pragmatic or utility considerations, so the choice of "logical analysis" is. The same goes for grammar, too, in Chomsky's sense, insofar as it reflects logical form or is expressed in some related notation.

The central point such a stance misses, as earlier emphasized, is that formal or syntactic structure is intended to be explanatory. Thus, one might find the positing of cognitively "hidden" syntactic structure to be "obscure," and in a sense it is, for we remain ignorant of how such structure is realized in the brain, but hypothesizing the structure is not "idle" since it does do explanatory work.

Here is Chomsky (1979, pp. 166–167; cp., Chomsky 1980, pp. 163–165) on how a variable logic stands toward natural language:

> [A] logic with variables and a logic without variables have the same expressive power. But if logical form [a grammatical level] is derived step by step, it turns out that a logic with variables is required to express certain general principles which explain facts of language … [A logic without variables] do[es] not furnish the types of representation

> appropriate for formulating rules that relate the surface structure to logical form in the most general way … As far as I can see, certain significant generalizations require a classical logic containing variables, where at times the variables reflect the presence of a trace in surface structure.

As will be recalled from Section 24.2, Chomsky (1955) had rejected the idea that logic should offer a direct insight into the nature of language. His early claim was that logic might aid the framing of general conditions a grammar must meet without offering insight into how grammars cleave to such conditions. Here Chomsky offers a proposal of exactly such a concordance between a general condition pertaining to operator-variable relations a grammar must satisfy, and a mechanism of how the condition is met, i.e. syntactic movement creates structures that are apt to be interpreted as quantifier/operator-variable relations, where the trace, *t*, of movement in the launch site is construed as a bound variable. For example:

(4) a. Who does Bill love?
b. (Which person *x*)[Bill loves *x*]
c. $[_{CP}$ Who$_i$ does $[_{TP}$ Bill love $t_i]]$

The question in (4a) is read as involving an operator-variable relation, as depicted in (4b), which is encoded in the syntactic structure (irrelevant detailed elided) in (4c). Why should we think that this hypothesis is "objective" rather than merely a paraphrase animated by pragmatic "advantages," such as to clarify the meaning of the original question? The simple reason is that it explains properties of the interpretation of (4a). There are many phenomena one could examine, but let us look at a feature that interestingly relates to a standard issue in logical theory via Chomsky's (1977) seminal discussion of *wh*-questions.

(4a) does not have a vacuous interpretation, even though the precluded interpretation is otherwise OK. That is, (4a) cannot be interpreted as in (5), even though (5) can be coherently answered:

(5) (Which person *x*)[Bill loves Mary]

This can be answered true or false. Suppose that Bill does love Mary; in that case, (5) can be truthfully answered with any name at all, for everyone is indeed such that Bill loves Mary. Likewise, if Bill doesn't love Mary, then the question can't be answered truthfully, for no-one is such that Bill loves Mary. Here we have an example of a syntactic condition precluding otherwise acceptable thoughts from linguistic expression. The hypothesized syntax explains the absence of vacuous readings precisely because the object slot of the verb *love* is bound by the fronted operator, even though the slot is phonologically null. Quine (1954) himself has discussed how vacuous quantification can apparently be true or false, depending on the status of the domain, and it is typical that formal systems either permit or exclude vacuous quantification on exactly pragmatic grounds (it simplifies well-formedness definitions to include vacuous quantification), for it makes no expressive difference to the system. In natural language, not so. Vacuous quantification is everywhere excluded.[4] The plot considerably thickens.

Consider:

(6) Who does Bill want to succeed?

The question is ambiguous between an asking after the person Bill wants to come after, where *succeed* is transitive, or an asking after the person Bill wants to do well, where *succeed* is intransitive. On the first transitive reading, *succeed* has two argument positions to be interpreted and both appear empty and so, it might seem, available to be co-interpreted with *who*, so that (6) could express a questioning of the object or subject of *succeed*. This is to forget about the role of *Bill*, however. (6), with *succeed* as transitive, can only be interpreted with *who* relating to the object position of the verb. This is because, if *who* were interpreted in the subject position of *succeed*, then the object position must be co-interpreted with *Bill*, but object positions cannot be interpreted in such a "control" manner. We see this by noting that (6) does not have a reading where a question is being asked about the person who wants to come ahead of Bill, as if it meant which person is such that Bill wants him/her to succeed Bill. On the second intransitive reading, *succeed* only has the subject position to be interpreted, and so it must be co-interpreted by *who*. Either way, no vacuity is possible, for *who* must be read as binding a position of *succeed*. Thus:

(7) a. (which person *x*)[Bill wants himself to succeed *x*]
b. (which person *x*)[Bill wants *x* to succeed]

If one position is overtly filled, the other becomes obligatorily linked to *who*, and if both are filled, the sentence is unacceptable, because vacuous:

(8) a. Who does Bill want Sam to succeed?
b. Who does Bill want to succeed Sam
c. *Who does Bill want Sam to succeed Mary?

Note further, a difference between these cases and (6). However the ambiguity of (6) is resolved, *Bill* must be read as the subject of *succeed*, if transitive; if intransitive, then only *who* can be co-interpreted with the sole argument position. Neither of the readings of (6) correspond in form to the cases in (8). In (8a), only *Sam* can be the subject of *succeed*, not *Bill*, and so *who* obligatorily interprets the object position.[5] In (b), *Bill* cannot be read as the subject either, because *who* must be linked to one of the respective positions of *succeed*, and the object position is already occupied. Thus, neither of the two readings of (6) corresponds to the meanings of (8a, b). This tells us that the positions of *succeed*, although "empty" in (6), cannot be read as contextually open or elliptical, as if their interpretation could be supplied by salient objects in a speaker's environment and so correspond to (8a, b). On the contrary, the possible interpretations of the positions of *succeed* in (6) are strictly constrained by the presence of the *wh*-item, and by the requirement that it relate to either of the positions.

Reflections of this sort can be multiplied almost indefinitely. Wherever one looks in language, one finds peculiar properties whose explanation calls for structural principles that make essential appeal to the interpretation of "empty" positions, and go beyond independent notions of sentence meaning or any utility of notation. Therefore, one need not tarry over questions of whether mentalism is "obscure" or how one might be a realist

about linguistic form. The simple fact is that the phenomena are real, and so whatever explains them can't be merely advantageous.

24.5 No Homeric Struggle

Strawson (1971) had suggested that there is a Homeric struggle between those who favor a formal approach to natural language and those who favor a communication-intention approach. Strawson aligns Chomsky with Frege in this division. Chomsky, as we have seen, is a formalist, but not as Frege or Russell or Carnap were, but as someone who grounds structural facts of language in the cognition of speaker–hearers. In this light, although Chomsky's thought has its foundation in the analytical tradition, it significantly departs from it, at least if we take Strawson's demarcation seriously.

For Chomsky, the proper role of formalism in the realm of natural language is the framing of structural constraints on the consumption and production of language, both of which are cognitive capacities. Semantics either falls into this realm, and becomes really structural, or else it dissolves into the nonlinguistic, dealing with how linguistic structures are put to use, subject to massive interaction effects that produce what is said by a speaker upon an occasion of use. The perception of Homeric struggle is perhaps due to language being often vicariously interesting for philosophy; that is, being formally explicit about how a discourse operates logically and semantically is taken to be a good way of understanding what the discourse is actually about, whether it be metaphysics, epistemology, ethics, psychology, and much about everything else. There was always a worry, however, going back to the semantic paradoxes, that natural language is heir to essential quandaries that formal systems are designed to elude. It is a grand philosophical achievement of Chomsky's to so much as entertain the idea that language is its own thing, an object of interest that may sustain deep inquiry regardless of its poor design relative to the ends to which formal systems are developed, and regardless, too, of whether ancient philosophical quandaries are resolved. After all, if language were a mere arbitrary, historically contingent and poorly designed communication system, why should philosophers much care for its nature, save to warn of the pitfalls that come from mistaking it as a true guide to meaning or the world or it being a mere vehicle for what is of real interest, such as thought? A still wider achievement is that Chomsky's approach freed philosophical inquiry from ungrounded assumptions about the nature of language: what appeared to be *a priori* truths turned out to be empirical falsehoods. Many new areas of investigation are opened up as a result, especially as regards the relation of syntax to meaning, the basis of both in cognition, and how the two are put to use by speakers. In this light, Chomsky is a major figure in the tradition, albeit one who disrupts its main lines of inquiry in ways that remain to be properly absorbed.[6]

Endnotes

1 See Coffa (1991, Chapter 2) for a philosophical discussion of the historical significance of the issue. Logicism has been pursued in many varied ways and remains, in some form, a live philosophical option.

2 The appeal to behavior as the grounding empirical condition was to be dropped. Chomsky (1954–55/75, pp. 101–103) was keen to stress the need for intuitive judgement as a data source, not least because the very criteria for selecting any behavioral test for grammaticality

depends on the speaker/hearer's linguistic judgement of grammaticality. That is, being grammatical cannot be reconstructed in behavioral terms. At this time, however, the dependence on intuition as data (not constitutive of the theory itself) was accepted with a certain regret that no alternative operational criteria were available. The attitude was soon to change with the rejection of the very idea of operationalizing the relevant theoretical notions (Chomsky 1964, pp. 56–59).

3 Quine's reference to "deep structure" is liable to confuse. Deep structure was posited by Chomsky (1965) as a level of syntactic representation prior to the application of transformations. It is natural, then, to conceive of semantic theory as tasked with assigning meanings to deep structures and charting the effects of transformations, an idea Chomsky (1957, p. 92) had already intimated. This became a full-blown hypothesis in the hands of Katz and Postal (1964), who claimed that transformations were semantically inert, so that the semantic properties of language are fixed by the interpretation of deep structure alone. Chomsky (1965) tentatively adopted this proposal. Soon after, however, deep structure itself became identified with semantic structure, and took on the form of a logic, developments which Chomsky demurred. Thus began the disputes between generative semantics and generative grammar (Newmeyer, 1980). At any rate, for present purposes, any formal conception of syntax may substitute for Quine's appeal to deep structure.

4 A ban on vacuous quantification is often assumed as a principle of the syntax-semantics interface (e.g. Chomsky 1982; May 1985). The assumption of a ban follows May's (1977, pp. 22, 46–47) proposal of a *condition of quantifier binding*, which says that "Every quantifier phrase must properly bind a variable," i.e., it must bind a variable it c-commands (May 1977, p. 22). May (1977, 46) remarks that this condition just amounts to the assertion that 'in natural languages, there is nothing comparable to the sort of "vacuous quantification" exhibited by logical formulae like $\forall x(2 + 2 = 4)$. May's essential point here is that if all syntactic scope-taking is derived from movement, syntactic vacuous quantification is impossible.

5 If we change the matrix verb to a so-called subject control verb, then interpretive possibilities change. Consider:

i. Who did Bill promise Sam to leave?

Here, *Bill* is interpreted as the subject of *leave* with *who* now obligatorily read in the object position (imagine Bill, who is married, is having a clandestine affair with Sam). Note that *leave* cannot be left intransitive; again, *who* must be interpreted nonvacuously.

6 My thanks go to Georges Rey for extensive discussion.

References

Carnap, R. 1928. *Der Logische Aufbau der Welt*. Leipzig: Felix Meiner Verlag. English translation by R. George, 1967. *The Logical Structure of the World. Pseudoproblems in Philosophy*. OaklandUniversity of California Press.

Carnap, R. 1934. *Logische Syntax der Sprache*. English translation by Amethe Smeaton, 1937. The Logical Syntax of Language. London: Routledge and Kegan Paul.

Chomsky, N. 1953. Systems of syntactic analysis. *Journal of Symbolic Logic* 18: 242–256.

Chomsky, N. 1954–55/75. *The Logical Structure of Linguistic Theory*. Chicago: University of Chicago Press.

Chomsky, N. 1955. Logical syntax and semantics: Their linguistic relevance. *Language* 31: 36–45.

Chomsky, N. 1957. *Syntactic Structures*. The Hague: Mouton.

Chomsky, N. 1959. A Review of B. F. Skinner's *Verbal Behavior*. *Language* 35: 26–58. Chomsky, N. 1964. *Current Issues in Linguistic Theory*. The Hague: Mouton.

Chomsky, N. 1965. *Aspects of the Theory of Syntax*. Cambridge: MIT Press.

Chomsky, N. 1977. On *wh*-movement. In *Formal Syntax*, edited by P. Culicover, T. Wasow, and A. Akmajian, 71–132. New York: Academic Press.

Chomsky, N. 1979. *Language and Responsibility*. New York: Pantheon Books.

Chomsky, N. 1980. *Rules and Representations*. New York: Columbia University Press.

Chomsky, N. 1982. *Some Concepts and Consequences of Government and Binding*. Cambridge: MIT Press.

Coffa, J. A. 1991. *The Semantic Tradition from Kant to Carnap: To the Vienna Station*. Cambridge: Cambridge University Press.

Frege, G. 1879. *Begriffsschrift*. Halle: Louise Nebert. Trans by S. Bauer-Mengelberg, 1967. Concept Script. In *From Frege to Gödel: A Source Book in Mathematical Logic, 1879–1931*, edited by J. van Heijenoort, 1–82. Cambridge: Harvard University Press.

Goodman, N. 1951. *The Structure of Appearance*. Cambridge: Harvard University Press.

Harris, Z. 1951: *Methods of Structural Linguistics*. Chicago: Chicago University Press.

Katz, J., and Postal, P. 1964. *An Integrated Theory of Linguistic Descriptions*. Cambridge: MIT Press.

May, R. 1977. *The Grammar of Quantification*. Unpublished PhD thesis. *MIT*.

May, R. 1985. *Logical Form: Its Nature and Derivation*. Cambridge: MIT Press.

Newmeyer, F. 1980. *Linguistic Theory in America: The First Quarter-Century of Transformational Grammar*. New York: Academic Press.

Quine, W. V. O. 1940: *Mathematical Logic*. Cambridge: Harvard University Press.

Quine, W. V. O. 1954. Quantification and the empty domain. *Journal of Symbolic Logic* 19: 177–179.

Quine, W. V. O. 1960. *Word and Object*. Cambridge: MIT Press.

Quine, W. V. O. 1972. "Methodological Reflections on Current Linguistic Theory. In *Semantics of Natural Language*, edited by D. Davidson and G. Harman, 442–454. Dordrecht: Reidel.

Russell, B. 1905. On denoting. *Mind* 14: 479–493.

Strawson, P. 1971. Meaning and truth. In *Logico-Linguistic Papers* 170–189. London: Methuen.

Wittgenstein. L. 1922. *Tractatus Logic-Philosophicus*. Trans, by C. K. Ogden. London: Routledge & Keegan Paul.

25

Chomsky on Meaning and Reference

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25.1 Introduction

Chomsky (1957, 1959, 1964, 1965) offered a fruitful conception of the languages that children regularly acquire and use in human speech. Given his emphasis on the importance of "syntactic" structures – and characterizing them formally, without appeal to any pre-theoretic notion of meaning – one might think that Chomsky was bracketing the "semantic" properties of words and phrases, in order to focus on intrinsic properties of linguistic expressions. But his claims about syntax were largely motivated by attention to the meanings that human grammars connect with pronunciations in distinctive ways. Chomsky also offered reasons for thinking that these meanings are intrinsic aspects of the expressions we can use to talk about aspects of our shared environment. Davidson (1967, 1973) and Lewis (1970, 1975) claimed that words have meanings by virtue of being related to sentences that are truth-evaluable because of how they are related to the world or worlds that we talk about; independently, Putnam (1975) concluded that meanings "ain't in the head." Chomsky (1977, 1980, 1995, 2000) challenged these externalist views in ways that drew on his earlier work, which can be viewed as a prolegomenon to a more internalist conception of meaning.

25.2 Data: Ambiguity and Absence

Using examples like the string of words shown in (1),

(1) the girl saw the boy studying in the library

Chomsky (1957, 1964) highlighted a phenomenon that he called "constructional homonymity." Speakers of English can hear (1) as a sentence whose meaning is roughly that of (1a),

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(1a) The girl saw the boy who was studying in the library.

or as a sentence whose meaning is roughly that of (1b).

(1b) The girl saw an episode of the boy studying in the library.

On the first reading, (1) implies that a boy who studied was seen, but not that any studying was seen. On the second reading, (1) does imply that the girl saw a boy *study*; cp. the corresponding reading of "caught the boy smoking." A third reading of (1) is indicated with (1c).

(1c) The girl saw the boy while she was studying in the library.

It's a familiar point that distinct words of a human language can be homonyms, and hence that the pronunciation of a string like (2) can be understood in several ways.

(2) the artistic sheriff drew his gun at the bank

Moreover, as Chomsky illustrated with "a name" and "an aim," a string of phonemes may be such that speakers can perceive it in more than one way with regard to word boundaries.[1] Similarly, a string of words may be segmentable into phrases in two or more ways. In (3), *with a name* can modify *horse* or *referred to the horse*.

(3) they referred to the horse with a name

In (4), "with style" can modify "name" or "referred to the horse with a name"; etc.

(4) they referred to the horse with a name with style

But this kind of ambiguity is also constrained.

Chomsky (1964) noted that (5) can be understood along the lines of (5a), but not (5b).

(5) John is eager to please
  (5a) John is eager to be one who pleases relevant parties.
  (5b) #John is eager to be one whom relevant parties please.

So (5) is interestingly *un*ambiguous. String (6) is also unambiguous, though in a different way.

(6) John is easy to please
  (6a) #It is easy for John to please relevant parties.
  (6b) It is easy for relevant parties to please John.

In (5), "to please" is understood as having "John" as its *subject*, with the implication that John is eager to do some pleasing; cp. "the duck is eager to eat." But in (6), "to please" is understood as having "John" as its *object*, with the implication that others can easily do some pleasing of John; cp. "the duck is easy to eat." By contrast with both (5) and (6), (7) is ambiguous –

(7) John is ready to please
  (7a) John is ready to be one who pleases relevant parties.
  (7b) John is ready to be one whom relevant parties please.

as if "ready" lets us understand "John" as the subject or the object of "to please," while "eager" supports only a "John"-as-pleaser reading, and "easy" supports only a "John"-as-pleased reading.

Chomsky (1964) also discussed strings like (8), which doesn't have the meaning indicated with (8a). Strikingly, (8) can only be understood along the lines of (8b).[2]

(8) this is the library the girl saw the boy studying in
  (8a) #This is the library such that the girl saw the boy who was studying in it.
  (8b) This is the library such that
    the girl saw an episode of the boy studying in it.

Two decades later, Chomsky (1981, 1986) emphasized constraints on how pronouns can be understood, using examples like (9–12); see Alexiadou and Lohndal (this volume).

(9) the mother wants the chick to feed herself
(10) the mother wants to groom the chick and feed herself
(11) the mother wants the chick to feed her
(12) the mother wants to groom the chick and feed her

In (9), "herself" must take "the chick" as its antecedent; the string has no second reading on which the pronoun is either bound to "the mother" or understood deictically like "this" in (8). String (10) is also unambiguous; though here, "herself" must take "the mother" as its antecedent. In (11) and (12), "her" can be understood deictically or as having an antecedent. But the antecedent can only be "the mother" in (11), and it can only be "the chick" in (12). This suggests that various features of human grammars are together imposing substantive constraints on how pronouns can be used to corefer with other expressions. But the relevant notion of coreference – antecedence or referential *dependence* – differs from the classic semantic notion of co-denoting, or having the same referent, which is neither necessary nor sufficient for antecedence.

Strings like (13) and (14) are subject to the same constraints as (9) and (10).

(13) the unicorn wants the round triangle to admire itself
(14) the unicorn wants to square the round triangle and admire itself

But since there are no unicorns or round squares, the pronouns have no referents. Moreover, a pronoun can be used (deictically) to refer to something that a speaker *also* refers to with another expression in the same sentence, as in (15) and (16); see Higginbotham (1983) for discussion.

(15) she is the chick's mother
(16) she has the mark that we saw on the chick's mother yesterday

In these cases, "she" cannot be understood as having an antecedent; cp. "her" in (11).

Stressing constraints on how expressions can be used and understood, as opposed to describing expressions in terms of alleged relations to language-independent entities, is a prominent feature of Chomsky's (1977, 1995, 2000) work on how meaning is (and isn't) related to reference. For example, he uses proper nouns like "London" to show that even when we use a name in a sentence, there may be no one thing that we are referring to. One can say that London is a heavily populated city on the Thames, that one has been there, and that the people of London could decide to move it elsewhere if the river rises – as if "London" can be used to talk about a place one can visit, or a polis that might be relocated. Similarly, we can use the common noun "book" to talk about certain abstract contents and/or spatially located vehicles of such contents. In talking about what to bring on a trip, a speaker might use (17).

(17) This book is lighter than the one that is better written,

with *one* functioning as a pronoun linked back to *book*.[3]

By identifying explananda with examples like (1–17), Chomsky also grounded his talk of meanings in detectable natural phenomena that are not idiosyncratic. Speakers differ in how they think about libraries and studying; given our varied histories, there are respects in which we attach different significance to a word like *eager* or *easy*; etc. But whatever meanings are, speakers of English can tell that (5) and (6) each have one meaning, while (7) has more than one.

(5) John is eager to please
(6) John is easy to please
(7) John is ready to please

There are two ways of understanding (7) and three ways of understanding (1).

(1) the girl saw the boy studying in the library

Yet (8) is less ambiguous than (1), much as (5) and (6) are less ambiguous than (7).

(8) this is the boy the girl saw studying in the library

These facts about meanings are data for theories of phrasal meanings.

For any language that a child acquires, each string of its lexical items will have n but not $n + 1$ meanings, for some number n. For examples of word salad, like (18), $n = 0$.[4]

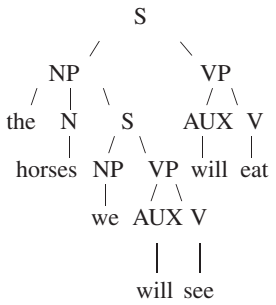
(18) studying the saw in girl library the boy the

As a matter of terminology, let's say that each *expression* has exactly one meaning, and that cases of phrasal homophony are cases of distinct expressions sharing a pronunciation. Examples like (1–18) suggest that acquiring a human language is a matter of acquiring a lexicon and a combinatorial procedure that can be used to generate complex expressions in ways that are somehow recursive but also interestingly constrained. Given finitely many lexical expressions, we can form boundlessly many others. But the combinatorial procedures that enable this capacity connect meanings with pronunciations in ways that allow for *and limit* homophony.

25.3 Strings and Constituents

Chomsky (1957) began by describing languages as sets of sentences, with sentences described as strings of "formatives." This familiar simplification was pedagogically useful. It let Chomsky distinguish importantly different kinds of recursive procedures, without yet discussing homophony; see Chomsky (1959), discussed in Hunter (this volume). But the idea was *not* that human languages are sets of intrinsically meaningless strings. The crucial point was that some but not all string-generators *impose constituency structure*, of the sort indicated with now familiar trees like (19), on the generable strings.

(19)



A procedure of the right kind can generate string (20) in a derivational way that treats "will eat" – but not "see will" or "horses we will" – as a *part* of (20).

(20) The horses we will see will eat.

Such a procedure can also generate (3) via distinct derivational routes: one that treats "horse with a name" as a part of (3); and another that treats "referred to the horse" as a part of (3).

(3) They referred to the horse with a name.

This suggested the beginning of an explanation for why a string like (21) has only the meaning indicated with (21a), as opposed to also having the meaning indicated with (21b).

(21) will the horses we see eat
  (21a) The horses we see will eat?
  (21b) #The horses we will see eat?

In (21), "will" is somehow mandatorily linked to the auxiliary position associated with "eat" in (19), as opposed to the "embedded" auxiliary position associated with "see" in (19).

Chomsky (1964) argued for analogous diagnoses of why (5) are (6) are unambiguous, each in their own way, even though (7) can be understood in the two ways noted in section one.

(5) John is eager to please

(6) John is easy to please
(7) John is ready to please

The idea was that (5) can only be generated in a way that links "John" to the subject position of "please," while (6) can only be generated in a way that links "John" to the object position of "please." This contrast presumably arises because "eager" signifies a kind of psychological readiness (cp. "an eager student"), while "easy" signifies a less agentive kind of readiness (cp. "an easy task"). But "ready" is somehow more flexible, and (7) can be generated in two ways. Likewise, Chomsky argued that the distinct readings of (1) reflect distinct structural analyses, while (8) is unambiguous because it can be only be generated in one way.

(1) the girl saw the boy studying in the library
(8) this is the library the girl saw the boy studying in

Subsequent work extended this line of thought to examples like (22) and (23).

(22) which building did the girl see the boy studying in
(23) that the girl saw the boy studying in

The question and the relative clause are both unambiguous in the striking way that (8) is.[5] Similarly, the unambiguity of (10) reflects constraints on how strings containing anaphoric pronouns like "herself" can be generated.

(10) the mother wants to groom the chick and feed herself

This wasn't – and still isn't – an account of what expression meanings are. But it does suggest that certain (constituency-imposing) *ways of generating strings* can at least serve as proxies for expression meanings, given a decent conception of lexical meaning. As we'll see, Chomsky (1957) offered some interesting remarks along these lines.

25.4 Lexical Meanings without Classical Extensions

In discussions of meaning, Chomsky often emphasizes complexities of usage and warns against theories that identify word meanings with sets of things that the words are allegedly "true of." But he grants that "[t]o understand a sentence we must know much more than the analysis of this sentence on each linguistic level. We must also know the reference and meaning of the morphemes or words of which it is composed (1957, pp. 103–104)." This point is presupposed in Chomsky's (1964) discussion of "eager" and "easy." Though unsurprisingly, he rejects certain conceptions of what it is to "know the reference and meaning of" an expression.

In a footnote attached to the word "meaning" in the passage just quoted, Chomsky cites Goodman (1949, 1953). He describes Goodman's work as

> reformulating a part of the theory of meaning in the much clearer terms of the theory of reference, just as much of our discussion can be understood as suggesting a reformulation of parts of the theory of meaning that deal with so-called "structural meaning" in terms of the completely nonsemantic theory of grammatical structure.

Chomsky then added that "meaning" is often used "as a catch-all term to include every aspect of language that we know very little about," and that we should expect various aspects of so-called theories of meaning to be "claimed by other approaches to language in the course of their development."

These remarks invite the project of *supplementing* an account of constructional homophony, in terms of how strings of words can be derived in constituency-imposing ways, with an account of how lexical items are used in acts of reference; cp. Strawson (1950). Though as Chomsky reminds us, expressions condition their use in complex ways. For example, a phrase like "the unicorn" can be the antecedent for a pronoun as in (24).

(24) the unicorn wanted to find the centaur and admire itself

But his warnings to remember – e.g., that linguistic *co*reference is possible in the absence of any referent – are not offered as arguments that sentence meanings are uninterpreted syntactic structures. Mere *ways of generating* strings of lexical items do not incorporate the meanings of the lexical items in question. The trick is to incorporate them in plausible ways that do not spoil accounts of constructional homophony and how it is constrained.

Goodman noted that despite the absence of unicorns, there are pictures of unicorns. These pictures are not pictures of centaurs; and pictures of centaurs are not pictures of unicorns. So the phrases "picture of a unicorn" and "picture of a centaur" can be used to talk about different things. Indeed, such talk can promote acquisition of the words "unicorn" and "centaur" if learners have an independent grip on what noun phrases of the form *picture of N* mean. But if these words have the same null extension, then since "picture of a unicorn" and "picture of a centaur" have the same syntactic structure, knowing what the phrases mean isn't a matter of determining their extensions on the basis of their shared phrasal structure and the extensions of the constituent lexical items. From this perspective, the words "unicorn" and "centaur" impose different conditions on reference because phrases like "picture of a unicorn" and "picture of a centaur" impose different conditions on reference. More generally, the idea was that two expressions can impose different conditions on use even if the expressions do not have distinct extensions: distinctions can be marked at various levels of syntactic complexity; and they can cascade down to distinctions in lexical meanings or percolate up to distinctions in sentence meanings.

Like Goodman, Chomsky rejected the option of characterizing the meanings of "unicorn" and "centaur" as distinct sets of possible beasts; cp. Lewis (1986). It's hard to see how the study of *language* could motivate appeal to possible worlds at which unicorns and centaurs exist; see Quine (1948). Moreover, as Chomsky (1957) noted, "colorless green idea" is a phrase whose meaning is like that of "revolutionary new idea"; and if meanings are sets of possible things, then a pronunciation with *n* distinct meanings is somehow associated with *n* distinct sets of possible things. But consider the pronunciation of (25), which is multiply ambiguous.

(25) a colorless green idea was ready to eat with a round square triangle

It isn't remotely plausible that there is a distinct set of possible things for each way of understanding this pronunciation. So why think lexical meanings are sets of possible things?[6]

While syntactic structure plays an important role in determining the conditions on reference that complex expressions impose, Chomsky denied that the semantic role of syntax is adequately characterized as a mapping from syntactic structures and extensions of lexical items to extensions of complex expressions. One might hope to set phrases of the form *picture of N* aside as special cases – along with instances of *took the horses to be Ns*, *thinks the cow is a(n) N*, *is a fake N*, and other examples of so-called referential opacity. But Chomsky's suspicion was that there is nothing special about complex expressions failing to have extensions that are determined (given syntactic structure) by lexical items with extensions that determine the extensions of complex expressions in which those lexical items appear. So instead of identifying meanings with (constituency-imposing) ways of generating expressions, or supplementing this unduly syntactic conception of meaning with appeal to alleged extensions of lexical items, Chomsky's hoped to supplement it with a notion of conditions on reference that allows for distinctions between extensionally equivalent lexical items.[7]

25.5 Complexities of Use

If referential contrasts between phrases can cascade down onto lexical items that would otherwise be referentially equivalent, then we shouldn't expect such contrasts to be compositionally determined. One can hope to provide a theory of understanding for a language by supplementing a theory of how complex expressions of the language are generated with a plausible specification of the relevant lexical meanings and how they interact with phrasal syntax. But these interactions are complicated. Chomsky (1995, 2000) observed that the phrase "painted the house" can be used to describe a process of applying paint to the *exterior* surface of a building, or the walls of rooms *inside* that building – or a *canvas*, in the course of depicting a house that may not exist. While we expect a gallon of red paint to be red throughout, and not just on the visible surface, we know that a red house (like a red apple) need not be red inside.

As noted in section one, we can use "book" to talk about spatiotemporally located things that carry inscriptions of certain contents, or abstract contents that get encoded in many ways and places. It seems that "book" lets us access different ways of thinking about the metaphysically various things that we call books. Even within a single sentence, we can use a single occurrence of "book" in more than one way. Recall (17).

(17) this book is lighter than the one that is better written

Likewise, "triangle" seems to let us access different ways of thinking about the metaphysically various things – perceptible inscriptions or imperceptible abstracta – that we call triangles. We can use "window" to describe an opening in a wall, a pane of glass that occupies such an opening, a display space behind such a pane at the front of a store, an opening in an envelope that makes an address visible, or a gap in a long counter at a bank. Most lexical items exhibit some such equivocality or *polysemy*, as indicated in dictionaries that often list subsenses for a single entry.

More generally, word meanings apparently allow for many dimensions of conceptual equivocality. This is potentially relevant to Putnam's (1975) widely endorsed claim that "water" has an extension – samples of H_2O, modulo impurities – and that (26) would be

false if used by a speaker of English on a planet where instead of H_2O, there is a distinct potable substance XYZ.

(26) There is water here.

In reply, Chomsky (1995, pp. 22–23) notes that adding a tea bag to a cup of tap water turns the water into tea. But suppose a second cup is "filled from a tap connected to a reservoir in which tea has been dumped (say, as a new kind of purifier)." This second cup contains water, not tea, even if the stuff in it is chemically indistinguishable from the stuff in the first cup. If a third cup contains pure H_2O into which a tea bag has been dipped, it is a cup of tea, though "it could have a higher concentration of H_2O molecules than what comes from the tap or is drawn from a river." In short, there are ordinary uses of "water" such that what counts as water *in this human sense* is a complicated matter having to do with sources and intended purposes. There are also scientific uses of "water" that abstract from these complexities, with the result that what counts as water *in this specialized sense* is clearer and less complicated: samples of H_2O, allowing for some stipulated range of impurities that are acceptable for the purposes at hand. But "water" supports various referential uses; see Pietroski (2017, 2018).

Lexical meanings somehow combine, in structured ways, to determine sentence meanings. But as Chomsky (1977) observed, (27) doesn't imply that any unicycle has wheels, while (28) implies that some mountains are climbed; cp. (29), which has a universal implication.

(27) Unicycles have wheels.
(28) Mountains are climbed by fools like me.
(29) Poems are written by fools like me.

Subsequent authors have offered various diagnoses of such examples; though the examples suggest that one way or another, sentence meanings can be sensitive to what Chomsky called "global properties" of sentences. He concluded that

> We cannot simply assign a meaning to the subject and a meaning to the predicate (or to a sentence form with a variable standing for the subject), and then combine the two. Rather, the meaning assigned to each phrase depends on the form of the phrase with which it is paired. (p. 31)

Of course, sentence meanings have aspects that are locally compositional. Chomsky's point is that they also have other aspects that influence conditions on reference.

> There is good evidence that words have intrinsic properties of sound, form, and meaning; but also open texture, which allows their meanings to be extended and sharpened in certain ways; and also holistic properties that allow some mutual adjustment. The intrinsic properties suffice to establish certain formal relations among expressions, interpreted as rhyme, entailment, and in other ways by the performance systems. (1996, p. 52)

As these passages make clear, Chomsky does not deny that words and phrases have meanings, or that we can study these semantic properties of expressions. On the contrary, Chomsky (1964) said that a grammar can be viewed as a "device for pairing phonetically represented signals with semantic interpretations, this pairing being

mediated through a system of abstract structures generated by the syntactic *component*," which interacts with what he called the semantic and phonological components, both of which count as "interpretive" in his sense (pp. 51–52, my italics).[8] This leaves room for proposals according to which the semantic interpretations are mentalistic, as in Katz and Fodor (1963). Chomsky (1957) hoped to make progress by specifying word meanings in terms of conditions on reference. But the idea was not that appeal to meaning should be eliminated from linguistic theory.

Rather, Chomsky urges us to "drop the empirical assumption that words pick out things, apart from particular usages, which they constrain in highly intricate ways" (1995a, p. 23). Skepticism about this assumption is a thread, connected to Wittgenstein (1953) and Austin (1961), that runs throughout Chomsky's discussions how grammatical form is related to linguistic meaning. Given a certain technical use of "semantics" due to Tarski – see Burgess (2008) for useful discussion – this might be described as skepticism about the hypothesis that a theory of meaning for a language naturally acquired by a human child will take the form of a semantics in the technical sense; cp. Davidson's (1967) bold conjecture that theories of linguistic meaning could indeed be, at their core, Tarski-style theories of truth. But Chomsky (1957) wasn't skeptical about the prospects for theoretical descriptions of linguistic meaning. On the contrary, he offered a potentially useful starting point by *not appealing* to pretheoretic notions of meaning in characterizing derivations of word-strings, which pair their meanings with pronunciations in ways that allow for phrasal homophony.

The picture that emerges is one in which the phenomenon of linguistic meaning arises from interactions between (i) the human computational system that lets us recursively combine lexical items in certain limited ways, and (ii) acquired lexical items that exhibit various kinds multidimensionality because of how human conceptual systems operate. On this view, meanings compose in empirically discoverable ways. But lexical meanings don't determine extensions or referents, and sentence meanings don't determine truth conditions. The relation between (i) and (ii) is complicated. As Chomsky (1957, p. 108) put it:

> Description of meaning can profitably refer to this underlying syntactic framework, although systematic semantic considerations are apparently not helpful in determining it in the first place . . . .Nonetheless, we do find many important correlations, quite naturally, between syntactic structure and meaning; or, to put it differently, we find that the grammatical devices are used quite systematically. These correlations could form part of the subject matter for a more general theory of language concerned with syntax and semantics and their points of connection. (p. 108)

Endnotes

1 Much as a Necker cube can be seen in two ways with regard to apparent orientation in space.

2 Chomsky (1964) also noted that a string like "what did the girl see the boy reading" can be used to ask which thing is such that she saw him *read* it – but not which thing is such that she saw the boy *who was reading* it. This suggests a common constraint on the interpretation of relative clauses and questions; see Ross (1967). See Berwick et. al. (2011) for a review, including recent developments and replies to some critics of the original arguments. For discussion of the relevance of event variables in accounting for constraints on homonymity, see Higginbotham (1985) and Pietroski (2018).

3 Cp. Pietroski (2005) and the contrast between the jarring "France is a hexagonal republic" and the less odd "France is a hexagonal, and it is also a republic."

4 But a string can be both grammatically defective and comprehensible. We can understand "the child seems sleeping." Indeed, we understand it as meaning that the child seems to be sleeping, *and not* that the child seems to be sleepy. So even a defective string can be interestingly unambiguous. See Higginbotham (1985).

5 See Berwick et. al. (2011) for review and discussion of why the underlying phenomenon is still relevant in debates concerning the *kinds* of recursive procedures that children can and do regularly acquire as grammars.

6 Davidson (1967), who was also skeptical of traditional appeals to meanings and possibilia, said that "recent work by Chomsky and others is doing much to bring the complexities of natural languages within the scope of serious semantic theory;" cp. Montague (1974). Davidson hoped for a "rapprochement" between his truth-theoretic conception of semantics and Chomsky's conception of syntax; see also Higginbotham (1985), Larson and Segal (1995). But according to Chomsky (1996, p. 52), "we cannot assume that statements (let alone sentences) have truth conditions. At most, they have something more complex: 'truth indications', in some sense."

7 That said, one can and should ask if this individuates meanings too finely. Perhaps "Romeo loves Juliet" and "Juliet was loved by Romeo" have the same meaning, despite differing structurally. Talk of transformations was supposed to help here. While the details have changed as conceptions of "alternations" have evolved, the idea has long been that structurally distinct derivations could be semantically alike by virtue of sharing a common core, perhaps specified in terms of a notion like "deep structure." Some aspects of syntactic structure may not be semantically relevant.

8 Chomsky (1986) introduced the technical term "I-language" to talk about expression-generating procedures that connect meanings with pronunciations in certain ways. The "I" echoes Church's (1941) notion of a function in *intension* (as opposed to extension); the relevant languages also seem to be individualistic and internalized. Lewis (1970, 1975) identified the languages we acquire with sets of string-meaning pairs – where the strings are sentential, and the meanings are (extensional mapping from contexts to) sets of possible worlds – and he spoke of communities "selecting" languages by establishing conventions. Chomsky (1980) argued that the theoretically interesting aspects of linguistic form and meaning are not conventional. But even if one adopts technical notions of language and sentence, stipulating that languages are sets of sentences, Chomsky (1957) showed that one is quickly led to the conclusion that acquiring and having a language like English is a matter of implementing an expression-generating procedure of a certain kind.

References

Austin, J. 1961. *Philosophical Papers*. Oxford: Oxford University Press.

Berwick, R., P. Pietroski, B. Yankama, and N. Chomsky. 2011.Poverty of the stimulus revisited. *Cognitive Science* 35: 1207–1242.

Burgess, J. 2008. Tarski's tort. In *Mathematics, Models, and Modality*.Cambridge: Cambridge University Press.

Chomsky, N. 1957. *Syntactic Structures*. The Hague: Mouton.

Chomsky, N. 1959. *On certain formal properties of grammars. Information and Control* 2:137–167.

Chomsky, N. 1964. *Current Issues in Linguistic Theory*. The Hague: Mouton.

Chomsky, N. 1965. *Aspects of the Theory of Syntax*. Cambridge, MA: MIT Press.

Chomsky, N. 1977. *Essays on Form and Interpretation*. New York: North Holland.

Chomsky, N. 1980. *Rules and Representations*, New York: Columbia University Press.

Chomsky, N. 1981. *Lectures on Government and Binding*. Berlin: de Gruyter.

Chomsky, N. 1986. *Knowledge of Language*. New York: Praeger.

Chomsky, N. 1995. "Language and Nature." *Mind* 104: 1–61.

Chomsky, N. 1996. *Powers and Prospects*. Boston: South End Press.

Chomsky, N. 2000. *New Horizons in the Study of Language and Mind*. Cambridge: Cambridge University Press.

Church, A. 1941. *The Calculi of Lambda Conversion*. Princeton: Princeton University Press.

Davidson, D. 1967. Truth and meaning. *Synthese* 17: 304–323.

Davidson, D. 1973. Radical interpretation. *Dialectica* 27: 314–328.

Goodman, N. 1949. On likeness of meaning. *Analysis* 10: 1–7.

Goodman, N. 1953. On some differences about meaning. *Analysis* 13: 90–96.

Higginbotham, J. 1983. Logical form, binding, and nominals. *Linguistic Inquiry* 14: 395–420.

Higginbotham, J. 1985. On semantics. *Linguistic Inquiry* 16: 547–593.

Katz, J., and J. Fodor. 1963. The structure of a semantic theory. *Language* 39: 170–210.

Larson, R. and G. Segal. 1995. *Knowledge of Meaning*. Cambridge: MIT Press.

Lewis, D. 1970. General Semantics. *Synthese* 22: 18–67.

Lewis, D. 1975. Languages and language. *Minnesota Studies in the Philosophy of Science*, Volume 7, edited by K. Gunderson, 3–35. Minneapolis: University of Minnesota Press.

Lewis, D. 1986. *On the Plurality of Worlds*. Oxford: Blackwell.

Montague, R. 1974. *Formal Philosophy*. New Haven, CT: Yale University Press.

Pietroski, P. 2005. Meaning before truth. In *Contextualism in Philosophy*, edited by G. Preyer and G. Peters, 253–300. Oxford: Oxford University Press.

Pietroski, P. 2017. Semantic internalism. In *The Cambridge Companion to Chomsky*, edited by J. McGilvray, 196–216. Cambridge: Cambridge University Press.

Pietroski, P. 2018. *Conjoining Meanings*. Oxford: Oxford University Press.

Putnam, H. 1975. The meaning of "meaning." In *Language, Mind and Knowledge*, edited by K. Gunderson, 131–193. Minneapolis: University of Minnesota Press.

Quine, W. 1948. On what there is. *The Review of Metaphysics* 2: 21–38.

Ross, J. 1967. *Constraints on variables in syntax*. Doctoral dissertation, Massachusetts Institute of Technology. Published as, Ross, J. 1986. Infinite syntax! Norwood, NJ: Ablex.

Strawson, P. 1950. On referring. *Mind* 59: 320–344.

Wittgenstein, L. 1953. *Philosophical Investigations*. New York: Macmillan.

26

Chomsky on Semantics[1]

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Semanticists will often casually remark that Chomsky—notoriously—rejects semantics. As a casual remark, there is something to this. Chomsky has explicitly argued against some central components of truth-conditional semantics. Chomsky has also frequently noted how poorly understood some aspects of semantics are, and has shown little inclination to grant the status of reasonably well-developed science to many parts of semantics. Where he is more optimistic, he has suggested that what we find is "basically syntax" anyway. Skepticism about semantics is certainly among Chomsky's views, and so the casual remark semanticists often make is fair enough.

But the casual remark is also certainly too casual. Chomsky has discussed semantics frequently, from the very beginning of his work, and in many ways, semantics has played a central role in a number of key Chomskian arguments. From early on, what meanings sentences can have has been central data for Chomsky. Chomsky has also dedicated a great deal of attention to how the interface between syntax and semantics is structured. For all Chomsky's skepticism about many aspects of truth-conditional semantics, he has never really dismissed the importance of semantics for understanding language.

26.1 Skepticism and Autonomy

Early and late, Chomsky has expressed some degree of skepticism about semantics. Here are some representative samples:

> There is, however, little evidence that "intuition about meaning" is at all useful in the actual investigation of linguistic form. (Chomsky 1957, p. 94)
>
> On the contrary, the problem of delineation [of syntax and semantics] will clearly remain open until these fields are much better understood than they are today. (Chomsky 1965, p. 159)

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> [Of Semantics:] No area of linguistic theory is more veiled in obscurity and confusion, and it may be that fundamentally new ideas and insights will be needed for substantial progress to be made in bringing some order to this domain. (Chomsky 1972, p. 75–76)
>
> [Of the syntax-semantics interface:] Important obscure questions still lie beyond: in what respects, for example, do these properties belong to the language faculty as distinct from other faculties of mind to which it is linked? (Chomsky 2000, p. 129)

It is easy to see the skeptical tone of these and other remarks. At the very least, semantics remains in a very underdeveloped state compared to, say syntax or phonology.

As we will discuss more below, Chomsky does reject a particular, well-developed program in semantics. Leaving that aside, Chomsky finds the subject of semantics in a poorly developed state. He often describes semantics as "obscure," and not up to the standards of good science.

But it also should be noted that the quotes above are almost all from discussions of something other than semantics in general. He is often really talking about the nature of syntax, or the language faculty, or the syntax-semantics interface. It is hard to find any place where Chomsky discusses semantics in isolation.

Moreover, Chomsky's skepticism about semantics as a science or its place in grammar does not mean he suggests there is "no such thing as semantics." Of course there is. Chomsky frequently refers to a traditional idea of a language as a pairing of sound *and meaning* (e.g. Chomsky 1972, p. 62):

> A grammar of a language, in the sense in which I will use this term, can be loosely described as a system of rules that express the correspondence between sound and maning in this language.

Even less skeptically, we find (Chomsky 1975a, p. 21):

> I will merely emphasize again that the "legitimacy of semantics" (whatever that might mean) has never, to my knowledge, been challenged, nor has there ever been any question of the importance of incorporating a study of reference, meaning, language use, and related topics within a full theory of language that will deal, in particular, with the highly significant relations between formal structure and semantic interpretation.

Chomsky, as we will discuss more below, is very concerned about how much of meaning is part of the language faculty proper. But he never says there is no such thing as meaning, or that it is not central to language.

One specific reason Chomsky has often voiced skepticism about semantics is that he saw the wrong kinds of appeals to semantics in the wrong places. This involves the complex issue of the autonomy of syntax. In loose terms, this is the idea that syntax is not derivative on semantics. The autonomy thesis includes more specific claims; for instance, that grammatical sentences are not those that have semantic significance, and grammatical relations are not to be understood as semantic relations (Chomsky 1957, p. 94). Many of Chomsky's well-known examples, including *Colorless green ideas sleep furiously*, come from his discussion of the autonomy of syntax (e.g. Chomsky, 1957, 1965).

The autonomy of syntax is also a kind of methodological point. It requires formulating syntactic principles in syntactic terms, not semantic ones; and it requires separating out semantic evidence about what a sentence means from evidence about its structure. So, to illustrate, we must not be mislead by the semantic oddness of an idea being colorless and green to claims about the structure of this famous sentence. This is a difficult idea to state properly. One reason is that the autonomy of syntax as Chomsky sees it by no means precludes any appeals to meaning. The fact that *I almost had a book stolen* has *three* distinct meanings is an important piece of evidence. It helps us to discover that our grammar can generate at least three syntactic structures for this string. But this fact about English syntax is not to be reduced to some facts about meaning. Rather, once the syntactic facts are identified, they help explain the observation about meaning. Nor are we to reduce our appeals to what sentences can mean to observations about how easily we can identify meanings. The third reading of our sentence – that I nearly succeeded in stealing a book—is often not recognized by speakers without some prompting. We can explain all this better once we identify the three distinct syntactic strutures the sentence can have; and perhaps, note the pragmatic oddness of one of them.[2]

The arguments for the autonomy of syntax in Chomsky's early writing (Chomsky, 1957, 1965) have been described as part of an extended argument for the "existence of syntax" (Adger 2018). His discussions of semantics there, both more skeptical and less, often relate to where and how semantic evidence can be correctly used in the study of syntax, or more generally, linguistic competence. His skepticism often reminds us that on Chomsky's view, assumptions that phenomena are semantic can be unjustified, or obscure, and hinder progress.[3]

26.2 Syntax-Semantics Interface

We have already seen that among the issues that brings Chomsky to discuss semantics is the way that syntax and semantics relate. In a very abstract way, Chomsky's views on this matter have been consistent. A typical early statement is the very last paragraph of *Syntactic Structures* (Chomsky, 1957, pp. 107–108):

> In other words, one result of the formal study of grammatical structure is that a syntactic framework is brought to light which can support semantic analysis. Description of meaning can profitably refer to this underlying syntactic framework, although systematic semantic considerations are apparently not helpful in determining it in the first place … Nevertheless, we do find many important correlations, quite naturally, between syntactic structure and meaning; or, to put it differently, we find that grammatical devices are used quite systematically. These correlations could form part of the subject matter for a more general theory of language concerned with syntax and semantics and their points of connection.

Syntax generates grammatically well-formed structures – sentences if you like. These support semantic interpretation. As it is often put, they are in the inputs of semantic interpretation. As such, they must be suitable for interpretation. As Chomsky later puts it, they must be "legible" to the right systems of semantic interpretation (Chomsky, 2000, p. 9).

As is well-known, syntax in the Chomskian tradition has often appealed to a number of distinct syntactic levels, sometimes (though not wholly helpfully) called levels of syntactic representation. An important technical question that has been central to Chomsky's discussion of semantics is just what is the level at which semantic interpretation happens. To explain these issues and Chomsky's views on them, it will helpful to take an historical perspective, and document some interesting developments over the past years.

Chomsky's most extensive discussion of the syntax-semantics interface takes place in the period from around 1965 to 1980.[4] Those familiar will recognize this as the period in which the so-called Standard Theory emerged with the publication of *Aspects of the Theory of Syntax* (Chomsky, 1965), and developed into the so-called Extended Standard Theory and then into Government and Binding theory by the time of Chomsky (1981). This was a particularly interesting time for thinking about how syntax and semantics relate. The years just after *Aspects* were filled with optimism about the state of generative linguistics. It was what Partee (2015) calls the "Garden of Eden period."

The model of syntax in *Aspects* is rich in many ways, and it is impossible in this essay to do it full justice. But briefly, phrase structure rules build deep structures. A transformational component then builds surface structures from deep structures. Most importantly for our purposes, deep structure is the level of semantic interpretation, and surface structure of phonetic interpretation. Chomsky specifically says, "The deep structure of a sentence is submitted to the semantic component for semantic interpretation" (Chomsky, 1965, p. 135).

This is deceptively simple claim. It is complex syntactically, as the idea that the syntactic process goes first through phrase structure to form a distinct level of deep structure, and then through transformations to form surface structure, is a very substantial claim, not made explicitly in Chomsky (1957, 1975a).[5] More striking for our interests is that *Aspects* includes an ambitious semantic component. Chomsky explicitly endorses work of Fodor, Postal, and Katz on semantics (Katz and Fodor, 1963; Katz and Postal, 1964; Katz, 1972), and includes it in the *Aspects* model. Again, we cannot explore their theory in depth, but it is built around the idea of a structure of "semantic markers" like *human*, *animal*, etc., and further semantic distinguishers that refine contents. Semantics for larger phrases is generated compositionally by so-called "projection rules." Philosophers have asked, often, whether such markers can really provide meanings for sentences (e.g., Lewis, 1970). Regardless, the theory here is semantics in at least two senses: It compositionally projects meanings, and it is answerable to a range of semantic data, including ambiguity, entailment, and so on.[6]

For the moment, we will focus, as Chomsky does, on the syntax-semantics interface. The kind of compositional semantics developed by Fodor, Postal, and Katz did not only involve marker representations of meaning; it also involved compositional ways to project them. Along the way, it included the idea of adding some semantically relevant morphemes to deep structure that had not been placed there before, including negation and question morphemes. This allows, for instance, question-formation transformations to not change meanings. We thus reach the Katz-Postal hypotheses, that transformations do not change meanings. As transformations do not change meanings, the deep structures they apply to must express the meanings of sentences. Thus, deep structure is the level of semantic interpretation, or as we now say, provides the syntax-semantics interface. With this hypothesis in place, we get the elegant view of the relation between syntax and semantics of *Aspects*.

Chomsky makes some of his most positive-sounding remarks about semantics in *Aspects*. Among many (Chomsky, 1965, p. 144):

> To the extent that grammatical categories and relations can be described in language-independent terms, one may hope to find universal projection rules, which need not, therefore, be stated as part of a specific grammar.

Chomsky is here optimistic that some of semantics could be a full-fledged part of universal grammar.

The Katz-Postal hypothesis became a focus of much attention in the years after *Aspects*. Chomsky had already mentioned some potential complications in Chomsky (1965). But over the years a number of challenges appeared. As highlighted by Jackendoff (1972), passive transformations appear to have more effect on meaning than originally thought. Among the many challenges to the Katz-Postal hypothesis, Partee (2015) highlights issues with quantifiers, which are of special importance to truth-conditional semantics. These issues were uncovered by a number of authors (Karttunen, 1969; Lakoff, 1968; McCawley, 1971). One typical observation is that passivization more dramatically affects meaning when quantifiers are involved:

(1) a. i. John sank the boat.
  ii. The boat was sunk by John.
  b. i. Everyone in the room knows two languages.
  ii. Two languages are known by everyone in the room.

For the first pair, we might be tempted to say they are synonymous (at least, before we pay close attention to focus). But the second pair seems to rearrange quantifier scope, and so the claim of synonymy is much harder to sustain.[7]

There are two ways one can respond to this. One is to continue to hold on to the Katz-Postal hypothesis and change what we think deep structure is like to explain the apparent puzzles. This is, we might observe, extending one idea that lead to the *Aspects* model: including some extra morphemes in deep structure. The other is, of course, to give up on the Katz-Postal hypothesis and see more than deep structure as input to semantics.

Hence began what some have called the "linguistics wars."[8] A view, known as "generative semantics," opted for the first response.[9] Generative semantics had a number of important ideas, and as it is not Chomsky's view, I shall not go into it in any depth. Suffice to say that to sustain the Katz-Postal hypothesis, generative semantics made deep structure increasingly more abstract, and had it contain increasingly more specifically semantic elements. Deep structure in generative semantics began to look more like logic, and less like the phrase structure of a natural language; and, it began to look more like the semantic representation of a sentence, rather than the input to semantics.

In the period from the late 1960s to the late 1970s, especially in the essays in Chomsky (1972, 1977), Chomsky along with Jackendoff (1972) developed a response to generative semantics. Their view, sometimes called "Interpretive Semantics" or the "Extended Standard Theory" (in contrast to the Standard Theory of *Aspects*) holds that both deep and surface structure feed semantic interpretation. Deep structure, specifically, provides grammatical relations to semantic interpretation. As thematic role theory is developed (e.g. Fillmore, 1968; Gruber, 1965), this is increasingly seen as

representing thematic structure. But suface structure is at this point also a component of semantic interpretation, as quantifiers, focus, and so on are interpreted there.

Further developments from Chomsky (1977) lead to the idea that the semantic information encoded in deep structure is preserved in transformations, and that post-surface structure semantic organization is needed. This leads to the idea that there is a level of Logical Form (LF), that is the distinctive level of semantic interpretation May (1977, 1985). This becomes a part of both the Government and Binding theory (Chomsky, 1981), and the subsequent minimalist developments (e.g. Chomsky, 1995, 2000). Ultimately, the view that emerges with the Minimalist Program is that syntactic processes generate legible representations PHON and SEM, which are the interfaces with phonetic and semantic interpretation.

So far, we have been talking about a fairly technical issue, as much in syntax as semantics: what level of syntactic representation is the right one to input into semantic interpretation. But in resisting generative semantics, Chomsky is not only addressing this narrow question. He is also insisting that syntactic structure feeds semantic interpretation, but is not itself semantic in nature (as he said in earlier work as well). Syntax is not semantics. In fact, in the period where he is responding to generative semantics, Chomsky voices more skepticism about semantics than he did in *Aspects*. The quote above from Chomsky (1972) is illustrative. Another example is from Chomsky (1977, p. 31):

> But it seems plain that the syntactic structures are not a projection of the semantics, and that the relation between the "world of ideas" and the syntactic system is fairly intricate.

Part of Chomsky's skepticism about semantics is skepticism about an overly semantic approach to underlying syntactic structures. The dispute with generative semantics highlights this.

26.3 Chomskian Semantics?

We have now seen some of the sources of Chomsky's skepticism about semantics in grammar, but also that he is not dismissive of the idea that there is some form of semantics. Clearly he thinks it is a poorly understood subject, but we can still ask what semantics along Chomskian lines would look like.

The main hint about what a Chomskian semantics could be is that in Chomsky (1965) he endorses the Fodor, Katz, and Postal idea of semantic markers. These, as we noted, provide a range of semantic elements like *human* or *animal* that can be combined by composition rules. He continues to talk about various plausible features that might be part of a grammar. Chomsky (2000) mentions *animacy*, *artifact*, and *substance*.[10] So, we can assume a Chomskian semantics will include a range of appropriate semantic features, though just what they are is yet to be accurately determined.

To understand this idea for Chomsky, it is important to remember that when talking about language, Chomsky's main interest is in the *Language Faculty* (sometimes called the *Faculty of Human Language*). The way Chomsky thinks about the Langauge Faculty is itself a complicated issue, and I shall not try to delve into it too deeply. But to quickly note some crucial features: it is a distinct human cognitive system, that is substantially innate, and one whose principles and parameters make up Universal Grammar. For us,

the most important point is that the Language Faculty is an aspect of cognition. It is part of psychology (cf. Chomsky, 1986, p. 25). In works around this period, Chomsky introduces the term "I-language." An I-language is state of the Langauge Faculty as it develops. It is thus an internal (and intensional!) part of an individual's psychology.[11]

When Chomsky talks about semantics, he is mostly talking about something that can be part of the Langauge Faculty – part of I-language. This is not the whole story, of course. Chomsky frequently describes the syntax-semantics interface as the point where the Language Faculty will hand off legible structures to a *Conceptual-Intentional* system, where much of what we might think of as fixing meaning takes place (Chomsky, 1995, 2000). But within I-language itself, what we find are *semantic features*. What features are in I-language is an empirical question, but a good guide is that they are the semantic components of a sentence that are encoded in the grammar. Chomsky's example of substance illustrates this. Conceptually, we can distinguish substance from particular objects, even at a very young age. So, there is an important aspect of our ability to think about the world represented by this feature. But equally, languages grammaticalize a mass-count distinction that roughly encodes the substance-object distinction. So, we have good reason to think this feature is part of I-language.[12]

Semantics for Chomsky must be part of I-language: the part that provides useful information from the Language Faculty to the Conceptual-Intentional system. Clearly, on this view, semantics proper is a constraint on the full contents we attribute to what we say. How strong a constraint, Chomsky would say, is unknown, but likely to be fairly weak.

Indeed, I think Chomsky's view is that there is not really a separate study of semantics within I-language. One hint is that, as we already saw, where we are confident there are features, they have syntactic effects. More generally, it has been a consistent idea of Chomsky's that the mechanisms of grammar are autonomous. I-language is its own system. We see this, for instance, in Chomsky's response to generative semantics. Chomsky resists reading semantics back into what was then deep structure, and insists on purely syntactic processes generating an interface level for semantic interpretation.

In more recent work, this idea has been further clarified. Starting with the strong lexicalist view of syntax that emerges with Chomsky (1972), and through further development into the Minimalist Program (Chomsky, 1995), a clear picture of the abstract architecture of the Language Faculty emerges. Lexical items are essentially bundles of features: semantic and phonological. The Language Faculty is a computational system that generates legible structures of features from these, that are then fed to the interface systems (Conceptual-Intentional and Articulatory-Perceptual). Chomsky often stresses that it is an open question just what goes into this system, and the Minimalist Program is one that seeks to find the most optimum system, with the least apparatus. But it is clear that there is not really a separate semantics module in this picture. We are not expecting to find, for instance, modes of semantic composition distinct from syntactic ones. Some features will presumably be especially important for the Conceptual-Intentional system, some especially important for the Articulatory-Perceptual system, and some for computational engine itself. But still, grammar—syntax if you like—operates with features that include semantic ones.[13]

The Minimalist Program seeks to identify the optimal mechanisms for I-language (as an organizing principle for a research program, but also for reasons of understanding the evolution of language, as discussed in e.g. Hauser et al. (2002)). The very austere

picture of the Language Faculty *Narrow* that Hauser et al. (2002) describe, reducing it essentially to a recursion mechanism, may make us wonder how much semantic will be left in the final results. But more concretely, there has been a tendency among generative linguists, even though working squarely in semantics, to shift burdens of explanation from semantics to syntax. One good example is quantifier scope, which may seem like a semantic phenomenon, and can be treated as such. But work in the tradition of May (1977, 1985) offers an account of quantifier scope based on otherwise well-recognized syntactic processes. Logical Forms, on this view, syntactically encode scope. This approach has been integrated into many works in semantics (e.g. Heim and Kratzer, 1998).[14] Similar points can be made in a number of ares, including binding theory and constraints on co-reference.

This tendency leads some in the Chomskian tradition to hold that within linguistics, understanding semantic phenomena means making them syntactic. Chomsky himself says something like this. He mentions work on semantics by Larson and Segal (1995) and Pustejovsky (1995), and says (Chomsky, 2000, p. 174):

> This work could be considered syntax in the technical sense; it deals with the properties and arrangements of the symbolic objects … The same practice would be appropriate, I think, with regard to the work often called "natural-language semantics" and "lexical semantics." It can be regarded as part of syntax, but oriented to a different interface and different aspects of language use.

There is a strict Chomskyan view that at least what we understand of I-language semantics is really syntax anyway. Of course, many semanticists working in the Chomskyan tradition disagree (e.g. Heim and Kratzer, 1998; Partee, 2015). The most strictly Chomskyan approach to semantics would investigate syntax and its relation to the Conceptual-Intentional system. Work along these lines has been pursued by Pietroski (2010, 2012, 2018). Wellwood's work (e.g. Wellwood et al., 2018; Wellwood, 2019) is in a related vein, if not strictly Chomskyan.

26.4 Reference and Truth Conditions

So far, we have described some sources of Chomskyan skepticism about semantics, but also seen what semantics for Chomsky is. What has been missing, strikingly, is engagement with one of the most well-developed research programs in semantics, including semantics within the broad project of generative (Chomskyan) linguistics.

There are many traditions in semantics, and many current research programs in sematics are embedded in firmly anti-Chomskyan views of language in general.[15] But since pioneering work of Partee (Partee, 1973, 1975), many linguists have seen the project of truth-conditional semantics as part of generative linguistics, and as part of a broadly Chomskyan approach to language. It is no surprise that the much-cited textbook of Heim and Kratzer (1998) is called *Semantics in Generative Grammar*.[16] But Chomsky is skeptical of *this* sort of semantics, and is so for foundational reasons. Whereas many of Chomsky's remarks on semantics are cautious and guarded, it is clear that he really rejects some of the core ideas of this program.

Truth-conditional semantics, of couse, had its start in philosophy, especially in logic, and migrated to linguistics over the years. As is very familiar, it has two fundamental

ideas. First, the meaning of a sentence is (or at least determines) its truth conditions. Take a simple sentence:

(2) Max smokes.

In virtue of its meaning, this sentence is true in a range of conditions: those in which a certain individual, Max, has a certain property, smoking. This determines a set of conditions. If you like the apparatus of possible worlds, it determines a set $\{w$: Max smokes in $w\}$. But we do not need to worry about worlds: for our purposes, any way of representing truth conditions is fine. We can just as well (for our purposes) say:

(3) "Max smokes" is true if and only if Max smokes.

Truth-conditional semantics, of course, works with appropriate representations of truth conditions.[17]

The main project of truth-conditional semantics within linguistics is to explain how truth conditions are determined compositionally, from the meanings of the parts of sentence and the ways they combine. But what then are the meanings of the parts of a sentence? According to this approach, their contributions to truth conditions. Central to that is *reference*. We assume that certain terms refer to certain things. Proper names like *Max* refer to their bearers, for instance. In the tradition from Frege, we can then work out what many other terms must mean to determine truth conditions. Predicates must have meanings that when combined with the meanings of names in simple sentences give truth conditions. These are in effect properties.

As this idea has been developed both in philosophy and linguistics, it often (though not always) looks to assign semantic values to constituents of sentences, and present modes of composition to show how those values combine. It is useful to simplify, in the manner of many standard presentations of truth-conditional semantics, and look at the purely extensional fragment. In such a simplified setting, we can assign terms their referents, sentences a truth value (proxy for truth conditions), and predicates their extensions, often in functional form. We have something like:[18]

(4) a. [[smokes]] = $\lambda x.x$ smokes
b. [[Max]] = Max
(5) [[Max Smokes]] = [[smokes]]([[Max]])

The mode of composition here is function application, which generalizes to a large number of cases. As part of this approach, different types of semantic values are assigned to different constituents. Composition can be by function application, but given the range of semantic values, there are substantial questions to be asked about how semantic composition works. Obviously, the empirical richness of this sort of approach to semantics goes way beyond such a simple example, as any good textbook in semantics makes clear. But this is the motivating idea behind the project, and much of what Chomsky takes issue with is already present in such simple cases.

Chomsky has voiced concerns about this sort of semantics over many years. Generally, Chomsky rejects the idea that natural languages are like the formal languges studied by logicians. Early on, he responded to a paper by Bar Hillel (1954) that

suggested the formal syntax of logic, and the notion of consequence from logic, could be usefully combined with linguistics. Chomsky (1955) strongly disagrees, and rather claims that formal languages from logic have so little relation to natural language that such combinations would be fruitless. Montague (e.g. Montague 1970, 1973) took the opposite position, that natural languages are just like formal languages. There is little explicit discussion of Montague in Chomsky's work, but his rejection of Montague semantics may well come down to his reservations expressed in 1955.[19]

Chomsky's most extensive discussion of truth-conditional semantics is in Chomsky (2000). There, he rejects the project, on foundational grounds. Here is a much-quoted passage (Chomsky 2000, p. 132):

> As for semantics, insofar as we understand language use, the argument for a reference-based semantics (apart from an internalist syntactic version) seems to me weak. It is possible that natural language has only syntax and pragmatics; it has a "semantics" only in the sense of "the study of how this instrument, whose formal structure and potentialities of expression are the subject of syntactic investigation, is actually put to use in a speech community," to quote the earliest formulation in generative grammar 40 years ago …

Chomsky presents a battery of arguments for this claim, especially in Chomsky (2000). Not surprisingly, they have proved controversial. I shall review them quickly, as they have already been discussed at length (cf. Pietroski, this volume).

Chomsky's arguments center on terms that lack plausible referents, or underdetermine reference. Here is a typical passage (Chomsky, 2000, p. 172):

> Suppose Peter says that Joe Sixpack voted for a living wage because he's worried about his child's health. Are we entitled to conclude that Peter believes the world to be constituted of such entities as Joe Sixpack, living wages, and health, and relations like voting-for and worrying-about that hold among them?

Similar points are made in Chomsky (1981), using the term *flaws*, and a related one in Chomsky (1975b) using the term *cattle*. Ludlow (2011) calls the "implausible commitments" argument, as it seems implausible that we are committed to entities such as "Joe Sixpack" to which the term refers.

Chomsky takes polysemy to show us similar problems (e.g. Chomsky 2020, pp. 15–16):

> Suppose the library has two copies of Tolstoy's War and Peace, Peter takes out one, and John the other. Did Peter and John take out the same book, or different books? If we attend to the material factor of the lexical item, they took out different books; if we focus on its abstract component, they took out the same book. We can attend to both material and abstract factors simultaneously, as when we say that "the book that he is planning will weigh at least five pounds if he ever writes it," or "his book is in every store in the country."

Even when we can find referents for expressions that seem plausible, we cannot always systematically assign a coherent referent to a term, and the mechanisms of language do not seem to care.[20]

Any number of specific responses have been given to these sorts of arguments. One response, that terms like *Joe Sixpack* or *the average man* are not really referring

expressions to begin with, has been offered by Higginbotham (1985) and Kennedy and Stanley (2009). Whether polysemy really poses such a serious problem has been challenged by King (2018) and relatedly Kennedy and McNally (2010). Collins (2017b) replies. To say the least, whether arguments from difficulty in identifying semantic referents succeed has proved controversial.

Chomsky (2000, pp. 129–133, 177–181) also argues that there is no theoretical benefit to positing semantic values. He compares the idea with positing "phonetic values." So, he considers the idea that for an element *a* of a phonological form, we posit a phonetic value ★*a*. Nothing would be gained from doing so, he claims. Would we explain how speakers communicate with such a theory? They would recognize common phonetic values for expressions of their languages? This is a weak theory, as it really tells us little if anything about what happens when a hearer hears speech in ways that facilitate communication. Such a theory is just "spinning wheels" (p. 129) and there are "no proposals along these lines" (p. 178). Semantic values, and reference to them, is not better, according to Chomsky. It does not explain how speakers and hearers communicate, and it introduces a theoretically demanding notion of reference. The arguments from implausible committments and polysemy are taken to show that reference, as needed for such a theory, is just such a theoretically obscure and not well understood relation. Chomsky concludes there is little value to truth-conditional semantics (except, as we saw above, when it turns out to look like syntax).

There are relatively few explicit responses to this line of argument from practitioners of truth-conditional semantics. King (2018) takes up the issue most explicitly. Ludlow (2011) and Partee (1975) take up substantial alternatives, which we will explore in a moment. I think that much of the literature on truth-conditional semantics takes itself to be showing its utility. It is capturing aspects of the meanings we recognize words to have and how they compose, and is responsible to a wide range of data. Perhaps the most common response from the literature is to show how Chomsky's worry that there is no substantial theory may be incorrect.[21]

The discussion in Chomsky (2000) is primarily an explanation and defense of internalist view of language (along with forms of naturalism, anti-behaviorism, etc.). The status of truth-conditional semantics is one of many ideas in philosophy that Chomsky takes issue with as part of this defense. But as a number of commentators, notably King (2018) and Ludlow (2011) point out, rejecting truth-conditional semantics is part of that defense. Generally, Chomsky is rejecting the idea that external relations between speakers and things in the world is part of the scientific study of language (which is the study of I-language). Truth-conditional semantics is based on reference and other assignments of semantic values, so rejecting such external relations requires rejecting truth-conditional semantics on foundational grounds (as is made clear by King (2018)).

The most systematic reply to this line of argument I know is from Ludlow (2003, 2011). Ludlow grants that referential semantics may not be part of the *Narrow* Faculty of Language (e.g. Hauser et al., 2002). But he argues an internalist, psychologically based I-language approach still makes room for relational explanations in semantics, including reference. Ludlow notes instances where explanations of individualistic properties of organisms are best given in terms of relations to their environments. Ludlow (2011) also explores other ways we can think of the standard type-based apparatus of truth-conditional semantics in more interernalist ways. Not surprisingly, the foundational status of truth-conditional semantics within an I-language approach

remains contentious. Chomsky (2003) found Ludlow's response to the arguments we reviewed above unpersuasive. Ludlow (2011) replies to Chomsky that they have more force than Chomsky granted.

Chomsky's responses to more technical developments of truth-conditional semantics within linguistics have been limited. We already noted his approval of Larson and Segal (1995), but so long as it is viewed as syntax. Chomsky (1977, pp. 47–52) does discuss an analysis of the structure of noun phrases from Partee (1975). There Partee made the now classic proposal that semantic considerations show us that complex noun phrases have the structure [D NP], as in [$_{D}$ the [$_{NP}$ man who saw Mary]] (cf. Heim and Kratzer, 1998). Chomsky objects, partly on on technical grounds. He complains that Partee's analysis will fail on plural noun phrases. (Though more recent work on plurals leaves this claim contentious.) But much of his discussion is a defense of a strong autonomy of syntax, where such semantic considerations as Partee presented for syntactic structure have no place.[22]

Chomsky's skepticism about truth-conditional semantics has been, and remains strong. It is part of his defense of internalism and the autonomy of syntax, but remains among his more contentious views.

26.5 Conclusion

Generally, we have seen that Chomsky has had a great deal to say about semantics. Some of it is negative. He rejects truth-conditional semantics, generative semantics, and views that challenge a strong autonomy of syntax. He is doubtful that we know that much about semantics, and doubts it has much of a place in the Narrow Language Faculty. But all the same, Chomsky recognizes that meaning is one of the central aspects of language, and the correctly formulated scientific study of meaning has to be part of the broad project of understanding us as agents and language users.

Endnotes

1 My understanding of Chomsky has benefited from many discussions with John Collins, Jeff King, Terje Lohndal, Paul Pietroski, and Alexis Wellwood. Thanks to them for all the help, and especially to John and Terje for comments on an earlier draft of this paper.

2 Discussions of examples like these appear frequently in Chomsky's writing, from Chomsky (1965) to Chomsky (1986) and beyond. For more discussion, see Pietroski (this volume).

3 Chomsky's views on the autonomy of syntax relate to a wide range of empirical and methodological issues. For more discussion, see Adger (2018), Newmeyer (1998), and Pietroski (this volume).

4 For a more extensive historical overview, see Lasnik and Lohndal (2013). For some discussion of more recent issues, see Alexiadou and Lohndal (2017).

5 Specialists will note that implicit in Chomsky (1957) are some ideas that play a similar role; especially, the distinction between kernel sentences and T-markers. Also, the need for these levels is questioned in later work.

6 For an overview of the state of the art at the time, see Fodor (1977).

7 As Partee notes, Chomsky (1965) does note potential issues with quantifiers in footnote.

8 See Harris (1993), though in my personal experience, people who lived through those days disagree on whether there was a "war," and what it was about. Though many now reject the

Katz-Postal hypothesis, with the luxury of hindsight we can see how much of what was then seen as part of the "losing side" of the war has become important to much current linguistic thinking.

9 This view—a "movement" by some lights— is associated with Lakoff, McCawley, Ross, some early work of Dowty, some work of Bach, some work of Horn, and others. Some representative publications in generative semantics include Lakoff (1971, 1972), McCawley (1968, 1971, 1972), and Ross (1970, 1972).

10 For interesting recent work on the semantics and cognition of objects, substances, and events, see Wellwood et al. (2018). See also reference therein for the rich literature on these issues.

11 Chomsky (1986) is perhaps the canonical statement of this idea, but it is consistent across a range of Chomsky's writings including Chomsky (1965, 1977, 2000). For a good discussion of the complex issues surrounding the Langauge Faculty, see Collins (2004).

12 The literature of cognition of objects and substance is huge, as is the literature on mass versus count terms. See references in Wellwood et al. (2018).

13 Pietroski (2018) argues that we need to find modes of composition in the Conceptual System that track minimal syntactic operations. He argues forms of concept conjunction do just that.

14 But see Jacobson (2014) for a different view, which we might call more semantic?

15 So-called Usage-Based Theories (e.g., Tomasello, 2005) and construction grammars (e.g. Goldberg, 1995) have semantic components that are explicitly anti-Chomskyan. Cognitive Semantics and Frame Semantics (e.g., Fillmore, 1982; Talmy, 2000) are equally anti-Chomskyan. There are many approaches to semantics. For a good overview, see the chapters in Maienborn et al. (2011).

16 The same can be said for other textbooks, notably Chierchia and McConnell-Ginet (1990) and Larson and Segal (1995). Though she disagrees with many Chomskyans about the syntax-semantics interface, Jacobson (2014) is also within the broad enterprise of generative linguistics.

17 Of course, I am talking about the project started with Frege (1892) and Tarski (1935), developed by Carnap (1947), Cresswell (1973), Davidson (1967), Lewis (1970), and Montague (1973), and then many others. For some discussion of the different flavors of truth-conditional semantics, see my (2014). For more on how different flavors of semantics and the syntax-semantics interace relate, see Lohndal (2014).

18 Here I mostly follow the influential presentation of Heim and Kratzer (1998), though up to some notational details, you find something similar in many many works in semantics. Semantic values are indicated by double brackets [[·]]. In displays and formulas, I let context disambiguate use and mention, but where it is helpful, I put linguistic items in *italics*. Thus, [[Max]] is the semantic value of *Max*.

19 But see remarks in Chomsky (1980).

20 For an extensive discussion of this argument, see Collins (2017a). Related points are discussed at length in Pietroski (2003, 2018).

21 For the data in semantics, see Chierchia and McConnell-Ginet (1990) and Krifka (2011). The textbooks mentions above all illustrate many of the theories and solutions to problems offered by truth-conditional semantics. Within philosophy there has been more discussion of arguments like Chomsky's about reference, with an eye towards the issue of *contextualism*. Chomsky's arguments echo those of Travis (e.g. Travis, 2008), who argues for a form of radical contextualism according to which pragmatics rather than semantics is the key to meaning. Among many responses is Cappelen and Lepore (2005) as well as Kennedy and McNally (2010). For a recent, empirically informed discussion see Hansen (2018).

22 Partee (2015) describes herself as "surprised" by the strength of Chomsky's negative reaction, given the optimistic things he said about semantics in *Aspects*.

References

Adger David. 2018. The autonomy of syntax. In N. Hornstein, H. Lasnik, P. Patel-Grosz, and C. Yang, editors, *Syntactic Structures after 60 Years: The Impact of the Chomskyan Revolution in Linguistics*, pages 153–175. Berlin: de Gruyter.

Alexiadou Artemis and Terje Lohndal. 2017. On the division of labor between roots and functional structure. In R. D'Alessandro, I. Franco, and A. J. Gallego, editors, *The Verbal Domain*, pages 85–104. Oxford: Oxford University Press.

Bar Hillel Yehoshua. 1954. Logical syntax and semantics. *Language*, 30: 230–237.

Cappelen Herman and Ernie Lepore. 2005. *Insensitive Semantics*. Oxford: Blackwell.

Carnap Rudolph. 1947. *Meaning and Necessity*. Chicago: University of Chicago Press.

Chierchia Gennaro and Sally McConnell-Ginet. 1990. *Meaning and Grammar*. Cambridge: MIT Press.

Chomsky Noam. 1955. Logical syntax and semantics: Their linguistic relevance. *Language*, 31: 36–45.

Chomsky Noam. 1957. *Syntactic Structures*. The Hague: Mouton.

Chomsky Noam. 1965. *Aspects of the Theory of Syntax*. Cambridge: MIT Press.

Chomsky Noam. 1972. *Studies on Semantics in Generative Grammar*. The Hague: Mouton.

Chomsky Noam. 1975a. *The Logical Structure of Linguistic Theory*. Chicago: University of Chicago Press.

Chomsky Noam. 1975b. *Reflections on Language*. New York: Pantheon.

Chomsky Noam. 1977. *Essays on Form and Interpretation*. North-Holland, Amsterdam.

Chomsky Noam. 1980. *Rules and Representations*. New York: Columbia University Press.

Chomsky Noam. 1981. *Lectures on Government and Binding*. Dordrecht: Foris.

Chomsky Noam. 1986. *Knowledge of Language*. New York: Praeger.

Chomsky Noam. 1995. *The Minimalist Program*. Cambridge: MIT Press.

Chomsky Noam. 2000. *New Horizons in the Study of Language and Mind*. Cambridge: Cambridge University Press.

Chomsky Noam. 2003. Reply to Ludlow. In N. Hornstein and L. Antony, editors, *Chomsky and His Critics*, pages 287–295. Oxford: Blackwell.

Collins John. 2004. Faculty disputes. *Mind and Language*, 19: 503–533.

Collins John. 2017a. The copredication argument. *Inquiry*, 60: 675–702.

Collins John. 2017b. The semantics and ontology of the average man. *Journal of Semantics*, 34: 373–405.

Cresswell Max J. 1973. *Logics and Languages*. Methuen: London.

Davidson Donald. 1967. Truth and meaning. *Synthese*, 17: 304–323.

Fillmore Charles J. 1968. The case for case. In E. Bach and R. Harms, editors, *Universals in Linguistic Theory*, pages 1–25. New York: Holt, Rinehart, and Winston.

Fillmore Charles J. 1982. Frame semantics. In Linguisics Society of Korea, editor, *Linguistics in the Morning Calm*, pages 111–137. Seoul: Hanshin.

Fodor Janet Dean. 1977. *Semantics: Theories of Meaning in Generative Grammar*. Cambridge: Harvard University Press.

Frege Gottlob. 1892. Über Sinn und Bedeutung. *Zeitschrift für Philosophie und philosophische Kritik*, 100: 25–50. References are to the translation as "On Sense and Meaning" by M. Black in *Collected Papers on Logic, Mathematics, and Philosophy*. Oxford: Basil Blackwell, 1984. Edited by B. Mcguinness.

Glanzberg Michael. 2014. Explanation and partiality in semantic theory. In A. Burgess and B. Sherman, editors, *Metasemantics: New Essays on the Foundations of Meaning*, pages 259–292. Oxford: Oxford University Press.

Goldberg Adele E. 1995. *Constructions: A Construction Grammar Approach to Argument Structure*. Chicago: University of Chicago Press.

Gruber Jeffrey. 1965. *Studies in Lexical Relations*. Ph.D. dissertation, MIT.

Hansen Nat. 2018. Just what is it that makes Travis' examples so different, so appealing? In J. Collins and T. Dobler, editors, *The Philosophy of Charles Travis*, pages 113–134. Oxford: Oxford University Press.

Harris Randy Allen. 1993. *The Linguisics Wars*. Oxford: Oxford University Press.

Hauser Mark, Noam Chomsky, and W. Tecumseh Fitch. 2002. The faculty of language: What is it, who has it, and how did it evolve? *Science*, 298: 1569–1579.

Heim Irene and Angelika Kratzer. 1998. *Semantics in Generative Grammar*. Oxford: Blackwell.

Higginbotham James. 1985. On semantics. *Linguistic Inquiry*, 16: 547–593.

Jackendoff Ray S. 1972. *Semantic Interpretation in Generative Grammar*. Cambridge: MIT Press.

Jacobson Pauline. 2014. *Compositional Semantics*. Oxford: Oxford University Press.

Karttunen Lauri. 1969. Pronouns and variables. *CLS*, 5: 108–116.

Katz Jerrold J. 1972. *Semantic Theory*. New York: Harper and Row.

Katz Jerrold J. and Jerry A. Fodor. 1963. The structure of a semantic theory. *Language*, 39: 170–210.

Katz Jerrold J. and Paul M. Postal. 1964. *An Integrated Theory of Linguistic Description*. Cambridge: MIT Press.

Kennedy Christopher and Louise McNally. 2010. Color, context, and compositionality. *Synthese*, 174: 79–98.

Kennedy Christopher and Jason Stanley. 2009. On "average." *Mind*, 118: 583–646.

King Jeffrey C. 2018. W(h)ither semantics!(?). *Nous*, 52: 772–795.

Krifka Manfred. 2011. Varieties of semantic evidence. In C. Maienborn, K. von Heusinger, and P. Portner, editors, *Semantics: An International Handbook of Natural Language Meaning*, volume 1, pages 242–268. Berlin: de Gruyter Mouton.

Lakoff George. 1968. Pronouns and reference. parts I and II. Bloomington: Indiana University Linguistics Club.

Lakoff George. 1971. On generative semantics. In D. Steinberg and L. Jocobovits, editors, *Semantics: An Interdisciplinary Reader in Philosophy, Linguistics and Psychology*, pages 232–296. Cambridge: Cambridge University Press.

Lakoff George. 1972. Linguistics and natural logic. In D. Davidson and G. Harman, editors, *Semantics of Natural Language*, pages 545–565. Dordrecht: Reidel.

Larson Richard K. and Gabriel Segal. 1995. *Knowledge of Meaning*. Cambridge: MIT Press.

Lasnik Howard and Terje Lohndal. 2013. Brief overview of the history of generative syntax. In M. den Dikken, editor, *The Cambridge Handbook of Generative Syntax*, pages 26–60. Cambridge: Cambridge University Press.

Lewis David. 1970. General semantics. *Synthese*, 22: 18–67.

Lohndal Terje. 2014. *Phrase Structure and Argument Structure: A Case Study of the Syntax-Semantics Interface*. Oxford: Oxford University Press.

Ludlow Peter. 2003. Referential semantics for I-languages? In N. Hornstein and L. Antony, editors, *Chomsky and His Critics*, pages 140–161. Oxford: Blackwell.

Ludlow Peter. 2011. *The Philosophy of Generative Linguistics*. Oxford: Oxford University Press.

Maienborn Claudia, Klaus von Heusinger, and Paul. Portner, editors. 2011. *Semantics: An International Handbook of Natural Language Meaning*, volume 1. Berlin: de Gruyter.

May Robert. 1977. *The Grammar of Quantification*. Ph.D. dissertation, MIT.

May Robert. 1985. *Logical Form: Its Structure and Derivation*. Cambridge: MIT Press.

McCawley James. 1968. The role of semantics in grammar. In E. Bach and R. Harms, editors, *Universals in Linguistic Theory*, pages 124–170. New York: Holt, Rinehart, and Winston.

McCawley James. 1971. Where do noun phrase come from? In D. Steinberg and L. Jocobovits, editors, *Semantics: An Interdisciplinary Reader in Philosophy, Linguistics and Psychology*, pages 217–231. Cambridge: Cambridge University Press.

McCawley James. 1972. A program for logic. In D. Davidson and G. Harman, editors, *Semantics of Natural Language*, pages 498–544. Dordrecht: Reidel.

Montague Richard. 1970. English as a formal language. In B. Visentiniet, et al. editor, *Linguaggi nella Società e nella Tecnica*, pages 189–224. Milan: Edizioni di Comunità.

Montague Richard. 1973. The proper treatment of quantification in ordinary English. In J. Hintikka, J. Moravcsik, and P. Suppes, editors, *Approaches to Natural Language*, pages 221–242. Dordrecht: Reidel.

Newmeyer Fredrick. 1998. *Language Form and Language Function*. Cambridge: MIT Press.

Partee Barbara H. 1973. Some transformational extensions of Montague grammar. *Journal of Philosophical Logic*, 2: 509–534.

Partee Barbara H. 1975. Montague grammar and transformational grammar. *Linguistic Inquiry*, 6: 203–300.

Partee Barbara H. 2015. The garden of eden period for deep structure and semantics. In Á. Gallego and D. Ott, editors, 50 Years Later: Reflections on Chomsky's *Aspects* , pages 187–198. Cambridge, MA: MITWPL.

Pietroski Paul M. Chomsky on meaning and reference, this volume.

Pietroski Paul M. 2003. The character of natural language semantics. In A. Barber, editor, *Epistemology of Language*, pages 217–256. Oxford: Oxford University Press.

Pietroski Paul M. 2010. Concepts, meanings and truth: First nature, second nature and hard work. *Mind and Language*, 25: 247–278.

Pietroski Paul M. 2012. Semantic monadicity with conceptual polyadicity. In M. Werning, W. Hinzen, and E. Machery, editors, *Oxford Handbook of Compositionality*, pages 129–148. Oxford: Oxford University Press.

Pietroski Paul M. 2018. *Conjoining Meanings: Semantics without Truth Values*. Oxford: Oxford University Press.

Pustejovsky James. 1995. *The Generative Lexicon*. Cambridge: MIT Press.

Ross John Robert. 1970. On declarative sentences. In R. A. Jacobs and P. S. Rosenbaum, editors, *Readings in English Transformational Grammar*, pages 222–272. Walthan, MA: Ginn.

Ross John Robert. 1972. Act. In D. Davidson and G. Harman, editors, *Semantics of Natural Language*, pages 70–126. Dordrecht: Reidel.

Talmy Leonard. 2000. *Towards a Cognitive Semantics*. Cambridge: MIT Press.

Tarski Alfred. 1935. Der Wahrheitsbegriff in den formalizierten Sprachen. *Studia Philosophica*, 1: 261–405. References are to the translation by J. H. Woodger as "The concept of truth in formalized languages" reprinted in Tarski. 1983. *Logic, Semantics, Metamathematics*. Indianapolis: Hackett, second edition. Edited by J. Corcoran.

Tomasello Michael. 2005. *Constructing a Language: A Usage-Based Theory of Language Acquisition*. Cambridge: Harvard University Press.

Travis Charles. 2008. *Occasion-Sensitivity: Selected Essays*. Oxford: Oxford University Press.

Wellwood Alexis. 2019. The Meaning of *More* . Oxford: Oxford University Press.

Wellwood Alexis, Susan J. Hespos, and Lance Rips. 2018. How similar are objects and events? *Acta Linguistica Academica*, 65: 473–501.

27

Chomsky and Pragmatics[1]

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27.1 Introduction

Pragmatics is traditionally defined as the study of language use as opposed to language structure, but it is often more narrowly construed as the study of linguistic communication, or speaker's meaning, or overtly intentional communication (whether verbal or non-verbal). It has been approached in a variety of ways: as an extension of formal grammar, or as a branch of philosophy, sociolinguistics or cognitive science (Ariel 2010; Huang 2017).

The central problem for pragmatics is that what is communicated by an utterance may depart from, or go well beyond, the linguistically encoded meaning of the sentence uttered. As Chomsky (1995, p. 29) puts it, "If intuition is any guide, there seems to be a considerable gap between the semantic resources of language literally interpreted and thoughts expressed using them." Pragmatic processes crucially rely on background or contextual information supplied by the hearer, which may significantly affect the outcome of the comprehension process.

Since the pioneering work of Grice (1957, 1967, 1989), a main focus of pragmatics has been on how the hearer identifies implicitly communicated propositions, or *implicatures* (Allott 2018); however, in recent years there has been increasing interest in pragmatic contributions to explicit truth-conditional content, via disambiguation, reference resolution, adjustment (or modulation) of lexical senses, identification of 'unarticulated constituents', and so on (see Carston 2002; Horn and Ward 2004; Recanati 2004, 2010, and references therein). Despite the complexity of the tasks involved and the fact that required contextual information is generally not explicitly spelled out, successful comprehension typically takes place almost instantaneously. The central goal of pragmatics is to explain how it is achieved.

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Grice (1957) proposed a definition of *speaker's meaning*[2] based on the overt expression and inferential recognition of intentions. Although his own goals were largely philosophical, his ideas have inspired attempts to develop a cognitively plausible, empirically testable theory of overt intentional communication (see Wilson and Sperber 2012, Chapter 1, for an overview). Construed as a branch of cognitive psychology, pragmatics is the study of the cognitive systems apart from the I-language (on which see Allott, Lohndal and Rey introduction, Chapter 1 of this volume) and the parser (Kush and Dillon, Chapter 19 of this volume) which enable speaker and hearer (or communicator and audience) to co-ordinate on the intended interpretation, and this is how we propose to treat it here.

The paper is organized as follows. In the next section, we consider some of Chomsky's suggestions about how the cognitive systems underlying human abilities might be investigated. Chomsky is skeptical about the prospects for a cognitive science of pragmatics; in section 3, we discuss his reasons and consider how far this skepticism may be due to his particular conception of pragmatics. In section 4, we outline an approach to pragmatics that seems to be compatible with his general methodology and is based on an alternative conception of pragmatics that we sketch out.

27.2 Chomsky's Importance for Pragmatics as Cognitive Science

Pragmatics, construed as a branch of cognitive psychology, stands to benefit from advances in the cognitive sciences in the last half of the twentieth century, many of which were inspired by Chomsky's work.

One of Chomsky's suggestions is that the mind, like the body, may consist of a number of discrete systems or "organs", each with its own organizing principles:

> We may usefully think of the language faculty, the number sense, and others, as "mental organs", analogous to the heart or the visual system or the system of motor coordination and planning (Chomsky 1980, p. 39).

Apart from the faculties Chomsky mentions here, folk physics, folk biology, mindreading (or 'theory of mind') and a possible moral sense have been fruitfully approached along these lines (see Allott and Smith, Chapter 34 of this volume, for discussion and references). Evidence for a dedicated mental system may come from the fact that the associated ability is species-universal (barring pathology), works fast and automatically, dissociates from other mental systems, and exhibits regularities not found in other domains. The pragmatic ability is an obvious candidate for such treatment, and Chomsky speculates that there may be a dedicated communicative system:

> It could be that one of the systems that develops, either as a distinct module or a component of others, is the kind of "communicative competence" that enables us to use language coherently and in ways that are appropriate to situations … Whether this system, if it exists, is an "inferential, non-modular one" depends on the facts of the matter … My own personal impression … is that talk of "general inferential or problem-solving capacities" tends to be rather empty, and that when we investigate actual cases … , we find that specific mechanisms are assumed. (Chomsky in Stemmer 1999, p. 395)

Modular approaches to pragmatics have been explored by Kasher (1991), and by Sperber and Wilson (2002), who treat pragmatics as a sub-module of a more general mindreading module (perhaps itself part of a broader module for social cognition).

A second suggestion of Chomsky's is that idealization is essential to the systematic investigation of nature (see Allott, Lohndal, and Rey, Chapter 33 of this volume.) In order to develop an explanatory account by identifying underlying regularities, we need to abstract away from real but messy phenomena. Since human behavior – including communicative behavior – typically results from interactions among many mental subsystems, this is particularly true in cognitive science. But while the importance of abstraction is well recognized in generative linguistics, it is perhaps less so in pragmatics.

For instance, Gricean pragmatics is often criticized by discourse analysts for using artificial examples designed to illustrate theoretical points, rather than data drawn from recordings of real-life verbal exchanges (Taylor and Cameron 1987; Schiffrin 1994). However, the use of audio recordings and transcriptions of authentic conversations may in turn be criticized for abstracting away from the bodily movements and visual monitoring that video recordings would reveal. And video recordings fail to capture much of the personal and common history of the participants, which generally affects the outcome of their interaction; and so on. Since idealization cannot be avoided, choices have to be made about which idealizations are likely to be most fruitful. Currently, the main focus in pragmatics is on how interlocutors coordinate on the explicit truth-conditional content of utterances, together with a few determinate implicatures. However, it is important to consider how this account might be extended to cover the social and relational aspects of language use which, as Chomsky notes, are vital in face-to-face exchanges (see Sperber and Wilson 1997, 2015).

A third suggestion of Chomsky's (1965, p. 4) is about the importance of developing explicit theories. In the case of generative syntax, the contrast is with traditional grammars, which typically presuppose rather than explain the reader's intuitive knowledge of the core principles of language (Alexiadou and Lohndal, Chapter 3 of this volume). Sperber and Wilson (1986, p. 37) make a similar point about Gricean explanations in pragmatics:

> Although based on an insight which seems quite correct, and although somewhat more explicit and systematic than the intuitive reconstructions supplied by unsophisticated speakers, the analyses of implicatures that have been proposed by pragmatists have shared with these reconstructions the defect of being almost entirely *ex post facto* …

In their view, the goal of pragmatics, as of generative syntax, should be to develop theories explicit enough to be empirically testable (see also Carston 2000).

The ideal of explicitness fits well with modelling cognition in terms of computations over representations (see Adger, Chapter 8 of this volume.) Within this broad picture, there are various understandings of the explanatory role of the computations and representations postulated by linguists and other cognitive scientists. For instance, the principles of pragmatics may be merely instantiated by the pragmatic system rather than explicitly represented: that is, they may be neither known by the person nor stored in a modular database, but simply express true generalizations about the way the pragmatic system operates (see Allott and Smith, Chapter 34 of this volume on the distinction).

Sperber and Wilson (2002/2012, p. 275) describe their own relevance-based pragmatic principle as instantiated by the pragmatic system rather than explicitly represented:

> We have suggested that [utterance comprehension] is based on a dedicated inferential procedure geared to considerations of relevance. These considerations are not spelled out and used as explicit premises in the procedure, but are built into its functioning instead.

27.3 Chomsky's Views on Pragmatics

27.3.1 Pragmatic Competence

From early on[3], Chomsky distinguished two aspects of the "implicit theory of the language" that a speaker acquires. One aspect "predicts the grammatical structure of each of an infinite class of potential physical events." The other specifies "the conditions for the appropriate use of each of these items" (Chomsky 1962, p. 528).

From the late 1970s, Chomsky described knowledge of this second aspect (i.e. knowledge of a "system of rules and principles" determining conditions for the appropriate use of language) as "pragmatic competence":

> For purposes of inquiry and exposition, we may proceed to distinguish "grammatical competence" from "pragmatic competence," restricting the first to the knowledge of form and meaning and the second to knowledge of conditions and manner of appropriate use, in conformity with various purposes. (Chomsky 1980, p. 224)

At this stage, he considers that there may be a distinct mental faculty for pragmatics ("It might be that pragmatic competence is characterized by a certain system of constitutive rules represented in the mind"), and sees this as an empirical hypothesis ("it is possible in principle for a person to have full grammatical competence and no pragmatic competence" (ibid, p. 59)). Later, he cites evidence that human pragmatic and conceptual systems taken together are distinct from I-language:

> There is reason to believe that the I-languages (grammatical competence) are distinct from conceptual organization and "pragmatic competence," and that these systems can be selectively impaired and developmentally dissociated. (Chomsky 1992a, p. 212)

Chomsky's remarks on pragmatic competence may have been influenced by the emergence of pragmatics as an area within linguistics at around this time. By the late 1970s, a generation of scholars were publishing in the field. Their work was strongly influenced by Grice's 1967 William James Lectures, which were circulating in manuscript and already published in part (Grice 1975; 1978). Chomsky (1980, p. 225) comments that pragmatic competence "may include what Paul Grice has called a 'logic of conversation,'" and while highly critical of Grice's account of speaker's meaning, he notes that "A theory of speaker's intention may well be a contribution to a theory of successful communication" (Chomsky, 1975, p. 64).

However, Chomsky's conception of pragmatics differs from Grice's in several respects. In the first place, Chomsky appears to see pragmatic competence as restricted to the use of language, whereas Grice's definition of 'speaker's meaning' is designed to cover

both verbal communication and a variety of non-verbal cases (see footnote 1 above and Section 27.4).

In the second place, Chomsky is keen to emphasize that language is not used purely for communication, and his notion of pragmatic competence is intended to cover the full range of uses, whether communicative or not[4]:

> I think a very important aspect of language has to do with the establishment of social relations and interactions. Often, this is described as communication. But that is very misleading, I think. There is a narrow class of uses of language where you intend to communicate. Communication refers to an effort to get people to understand what one means. And that, certainly, is one use of language and a social use of it. But I don't think it is the only social use of language. Nor are social uses the only uses of language. For example, language can be used to express or clarify one's thoughts with little regard for the social context, if any. (Chomsky 1984)

Language is also used for "internal thought," and Chomsky (in Stemmer 1999) describes this as much the most frequent use of language.

However, the greatest divergence between Chomsky and Grice is on the nature of meaning itself. Chomsky's views on meaning were strongly influenced by ordinary-language philosophers such as Austin and the later Wittgenstein ("I assumed from my earliest writings in the mid-1950s a kind of use theory of meaning" (Chomsky 2003, p. 295).) By contrast, one of Grice's main contributions was to argue, against the ordinary language philosophers, that use does not necessarily give direct insight into meaning and that it is important not to conflate the two.

To take just one illustration, Chomsky (1995, pp. 22–23) discusses a range of cases where the same liquid, with the same chemical composition, is appropriately described in some circumstances as *water* and in others as *tea* (see Pietroski, Chapter 25 of this volume, for discussion). Following the ordinary-language philosophers, Chomsky sees these facts about appropriate use as giving direct insight into the interest-relative nature of word meaning ("we find that whether something is water depends on special human interests and concerns"). Grice's aim was to isolate general principles of language use which strongly reflect "human interests and concerns", thus relieving semantics of the need to deal with such concerns on a word-by-word basis. His proposals have led to the development of a fruitful body of research on *lexical pragmatics* which explores how linguistically specified word senses may be pragmatically 'adjusted' or 'modulated' in the course of the comprehension process, contributing directly to explicit truth-conditional content rather than to implicatures (Carston 1997, 2002; Sperber and Wilson 1998, 2008; Recanati 2004, 2010; Wilson and Carston 2007).[5]

27.3.2 The Creative Aspect of Language Use

A notable development of Chomsky's views came with his discussion of linguistic creativity, the "creative aspect of language use," and the relation between them (Chomsky 1964, 1966, 1974, 1991). These ideas are developed at length in *Cartesian Linguistics* (1966).

A first kind of creativity, now usually called 'productivity' (Chomsky 1972, p. 92 n. 21), is the ability to generate an infinite number of sentence structures based on a finite system of rules and a finite stock of lexical items. This is evidenced by the ability to produce and parse novel sentences, and falls within the province of syntactic theory.

A second kind of creativity is what Chomsky calls "the creative aspect of language use": the ability to use language in ways that are infinite in scope and appropriate to circumstances, but not determined by them. Productivity is arguably a prerequisite for the creative aspect of language use, given that there is no particular bound on the circumstances we may face, but it clearly doesn't explain it (see Hymes 1974, p. 94). Chomsky cites as precursors Descartes and de Cordemoy, who both argued that the creative use of language cannot be explained by appeal to the actions of a mechanism, and treated it as evidence for a mind or soul. Chomsky agrees with the Cartesians' negative claim, but concludes that is impossible to give an explicit theory of the creative aspect of language use in terms of computations and representations.

As Chomsky notes, a device with an element of randomness may be stimulus-independent, and, as generative grammar shows, a "mechanical system could exhibit infinite diversity" (Chomsky 1974, p. 28). Equally, as Descartes pointed out, a mechanical device could produce appropriate responses to predetermined stimuli given a set repertoire of programmed responses. So the key feature of the creative aspect of language use is appropriateness of language use over an indefinitely wide range of circumstances. In terms of his well-known distinction between problems and mysteries (see Collins, Chapter 36 of this volume), Chomsky regards this as not a problem but a mystery. We return to this point below.

27.3.3 Against Pragmatic Theory

Chomsky consistently maintains that systematic investigation of the use of language has made little progress and may well be impossible (see Allott 2019 for discussion).

One reason he gives is that utterance interpretation involves interaction among many mental systems, and is too complex to be studied systematically:

> There is … a … problem, which we can formulate in vague terms but which cannot be studied in practice: namely to construct an "interpreter" which includes the parser as a component, along with all other capacities of the mind … and accepts non-linguistic as well as linguistic input. The interpreter, presented with an utterance and a situation, assigns some interpretation to what is being said by a person in this situation. The study of communication in the actual world of experience is the study of the interpreter, but this is not a topic of empirical enquiry for the usual reasons: there is no such topic as the study of everything. (Chomsky 1992b, p. 120)[6]

However, given Chomsky's remarks on the importance of idealization, there is no reason to assume that an explanatory pragmatic theory must deal with everything at once. The goal of the comprehension system is to infer the speaker's communicative intention. This system interacts with many others, combining linguistic information supplied by the parser with information derived from perception, inference, mindreading, and short- and long-term memory. Chomsky seems to have in mind a type of "contextual code model" in which the interpreter, "presented with an utterance and a situation," produces an interpretation as output. But contrary to what is often assumed, hearers are not "presented with" a determinate situation or context. They invariably have access to an indefinite range of potential contextual assumptions among which they have to choose in the course of the comprehension process, and one of the goals of pragmatics is to explain how this is done. This is one of several arguments

against code-based approaches to pragmatics. (For discussion, see Sperber and Wilson 1986, pp. 3–15, 24–28).

More generally, the most important feature of the comprehension process is that it takes place at a risk. While the hearer's goal in utterance comprehension is to identify the speaker's intended interpretation, there is no pragmatic code – no failsafe procedure which, barring performance errors, will correctly identify this interpretation. Comprehension is irredeemably a matter of non-demonstrative inference; its output is a hypothesis about the communicator's intentions which, however well evidenced, may not be correct. As Sperber and Wilson (1986, p. 45) put it,

> Failures in communication are to be expected. What is mysterious and requires explanation … is not failure but success.

Given that comprehension is fast, automatic, and species-universal (barring pathology), and given that the speaker's communicative intention cannot be decoded but only non-demonstratively inferred, it is reasonable to assume that hearers are equipped with a dedicated heuristic for constructing a hypothesis about the intended interpretation, using evidence drawn from a variety of mental systems. Showing what such a heuristic might look like, and how it might apply automatically to information derived from multiple sources would be a notable step towards an explanatory account of pragmatics.

A related, but logically distinct, argument is found in the work of Katz and Fodor (1963, pp. 178–179)[7], and Fodor (1983). In their view, since any type of information, from any source, may play a role in inferring a speaker's communicative intention, a rational hearer would have to consider every conceivable source of evidence in deciding what the speaker meant. Hence Fodor's First Law of the Non-Existence of Cognitive Science: "The more global … a cognitive process is, the less anybody understands it" (Fodor 1983, p. 107). This argument has been much discussed (see Allott 2019 for references), but there are two serious problems with it. First, rationality involves considerations of effort as well as effect; ignoring the effort factor is pathological (Sperber and Wilson 1996). Second, even if it were rational to consult all relevant evidence, it does not follow that this is what interpreters do. Cognitive pragmatics aims at a descriptive, not a normative account.

A third argument of Chomsky's is that language use is a mystery because it is a type of intentional action, and we have no theory of how people choose what to do. As he puts it, "theories of behavior will always miss the crucial point: the person could have chosen to act otherwise" (Chomsky 1996, p. 17). The connection with the creative aspect of language use is clear, and it contributes to Chomsky's skepticism about pragmatic theory:

> There is interesting work on precepts for language use under particular conditions – notably the intent to be informative, as in neo-Gricean pragmatics – but it is not at all clear how far this extends to the normal use of language, and in any event, it does not approach the Cartesian question of creative use, which remains as much of a mystery now as it did centuries ago. (Chomsky 2010, p. 29)

We might grant for the sake of argument that human free choice of action cannot be scientifically studied, but it does not follow that either utterance interpretation or utterance production is equally inscrutable. In the case of utterance interpretation, issues of free will do not seem to arise, and the vast majority of work in linguistic

pragmatics has focused on comprehension rather than production. We turn to this research program in the next section. The pragmatics of utterance production has been studied much less, but it seems possible in principle to separate out the factors influencing (a) the formation of a communicative intention and (b) the construction of an utterance that expresses this intention (Kasher 1991, p. 141; see Pollard 2015 for interesting recent work on utterance production).

27.4 Critique of Chomsky's Conception of Pragmatics

27.4.1 The Aims and Scope of Pragmatics

Pragmatics may be more or less broadly conceived. It has been seen as a theory of language use (as in Chomsky's work) or a theory of 'speaker's meaning' (as in Grice's work). We want to show that neither approach is entirely adequate, and that pragmatics is best conceived as a theory of overt intentional (*ostensive*) communication which covers cases of *showing that* (e.g. holding up an empty glass to show that it is empty) as well as *meaning that* (e.g. saying "Yes, please," meaning that you'd like another drink), since both are deliberate and open attempts to convey information.

According to Chomsky (1980, p. 225), pragmatic competence "places language in the institutional setting of its use, relating intentions and purposes to the linguistic means at hand." This fits well with traditional definitions of pragmatics as the study of language use. As noted above (Section 27.3.1), Chomsky sees the communicative use of language as only one of several social uses, and treats all such uses as falling within the domain of sociolinguistics:

> There is undoubtedly much to learn about the social uses of language, for communication or for other purposes. But at present there is not much in the way of a theory of sociolinguistics, of social uses of languages, as far as I am aware. (Chomsky 1984)

There is interesting work in sociolinguistics with implications for pragmatics (see, for instance, Brown and Levinson 1987). However, when it comes to explaining how speakers and hearers coordinate on the intended interpretations of utterances, sociolinguists have had little original to propose, and tend to rely on models of communication imported from elsewhere.

Pragmatics is now more commonly defined as the study of the context-dependent aspects of communication.[8] Here, Chomsky takes a more restrictive view of what counts as a specifically communicative use of language than many working in the field:

> I think the use of language is a very important means by which this species, because of its biological nature, creates a kind of social space, to place itself in interactions with other people. It doesn't have much to do with communication in a narrow sense; that is, it doesn't involve transmission of information. There is much information transmitted but it is not the content of what is said that is transmitted. (Chomsky 1984)

That is, while he sees communicative uses of language as necessarily involving "the transmission of information", he excludes cases where the speaker does not intend to communicate "the content of what is said." As a possible example of such a case, he mentions phatic communion – "informal conversation conducted for the sole purpose

of maintaining casual friendly relations, with no particular concern as to its content" (Chomsky 1980, p. 230). So a pragmatic theory restricted to explaining Chomsky's "communicative uses of language" would be mainly concerned with how speakers and hearers coordinate on "the content of what is said." This conception of pragmatics seems unduly restrictive: it is hard to see how a theory capable of explaining how contextual assumptions affect disambiguation, reference resolution, lexical adjustment and other pragmatic contributions to explicit truth-conditional content could fail to shed light on other aspects of communication, both verbal and nonverbal, and this possibility is worth exploring.

In Grice's framework, unlike Chomsky's, what is communicated depends on an intention of the speaker, which the hearer infers from the fact that the utterance has been made, on that particular occasion, in that tone of voice, with that facial expression, and so on. It is therefore possible for a Gricean speaker's meaning to depart from the linguistically specified meaning of the sentence uttered (as in figurative utterances), or to include implicated social information unrelated to "the content of what is said," as in the following example:

> At a genteel tea party, A says *Mrs X is an old bag*. There is a moment of appalled silence, and then B says *The weather has been quite delightful this summer, hasn't it?* B has blatantly refused to make what he says relevant to A's preceding remark. He thereby implicates that A's remark should not be discussed and, perhaps more specifically, that A has committed a social gaffe. (Grice 1969/1989, p. 35).

As Chomsky points out, most utterances in face-to-face exchanges convey an element of social or relational information. Unless it is highly salient, as in Grice's example above, this is often abstracted away from in current approaches to pragmatics. To decide how such information should be dealt with in pragmatics, what we need is not more intuitions about what counts as a communicative use of language, but an explicit theory of communication.

Grice's own aim was not to build a theory of communication but to analyse the notions of sentence meaning and speaker's meaning. His definition of speaker's meaning was not intended to apply to all cases of overt intentional communication, but to pick out a subclass of cases in which the communicator can intuitively be described as *meaning that p* rather than merely *showing that p*.[9] This definition was much debated, and Grice himself pointed out a number of apparently insuperable problems with it (Grice 1969; Neale 1992). However, it is still widely seen as fundamental to modern pragmatics. As Stephen Levinson (2000, pp. 12–13) puts it:

> A theory of communication has as its target the full scope of Grice's (1957) non-natural meaning … [M]eaning$_{NN}$ (or something of the sort) draws an outer boundary on the communicational effects that a theory of communication is responsible for.

According to Sperber and Wilson, quite apart from its internal inadequacies, it is a mistake to treat Grice's notion of speaker's meaning as fundamental to pragmatics, since the same pragmatic principles and mechanisms apply to the full range of cases of overt intentional communication. Their aim is to develop a theory of *ostensive communication,* where the communicator overtly displays evidence of her intention to inform the addressee of something and the addressee infers this intention from the evidence provided (Sperber and Wilson 1986, pp. 21ff; 2015). The evidence displayed may be

verbal, nonverbal, or a mixture of both (Wharton 2009), and the information communicated – which is typically not a single proposition but an *array* of propositions – may include social or relational information that goes well beyond "the content of what is said," plus a few salient implicatures. Thanks to many years of collective endeavour by linguists, philosophers and psychologists, there is now considerable evidence for the existence of a dedicated mental system for ostensive communication, which is arguably unique to humans (Scott-Phillips 2014) and which follows different trajectories in typical and nontypical development.[10]

27.4.2 What Might a Theory of Ostensive Communication Look Like?

Ostensive communication starts with an *ostensive act*: an act designed to attract the addressee's attention and focus it on the communicator's intentions. Common cues to ostension include catching someone's eye, touching them, pointing, showing them something, speaking and writing. Following Grice's suggestion that attempts at overt intentional communication create certain pragmatic expectations in the addressee, we assume that the goal of the comprehension system is to construct an interpretation that satisfies those expectations, based on clues provided by the communicator, together with contextual information. A major task for pragmatic theory is to describe those expectations and explain how they may be satisfied in the course of the comprehension process.

As suggested above (Section 27.3.3), given that comprehension is largely a fast. automatic, unreflective process, it is natural to assume that it is carried out by a heuristic which does not process a great deal of information that could in principle be brought to bear[11] (Sperber and Wilson 1986, p. 45; on such heuristics see Todd and Gigerenzer 2000, pp. 729–730); and that the system does not calculate for each item of information that could be processed whether it is worth considering, since this is generally prohibitively costly (Vriend 1996, p. 278; Todd and Gigerenzer 2000, pp. 729–730; Allott 2008, pp. 170–172). There must also be a rule that stops the search (Allott 2008, 179ff.).

Relevance theory proposes one such heuristic, guided by considerations of effort as well as of expected effect. This heuristic is designed to take advantage of a regularity in the domain of overt intentional communication – that the communicator, wanting to be understood, has done her best to put the addressee on the right track, so that the first pragmatically plausible interpretation to occur to him (i.e. the first to satisfy his pragmatic expectations) is the one she intended to convey. Sperber and Wilson argue that this means that the heuristic, on a first pass[12], can simply follow a path of least effort in constructing a hypothesis about the communicator's intended interpretation, testing candidate disambiguations, reference resolutions, lexical modulations, contextual assumptions and implications in order of salience or accessibility, and accepting the first interpretation reached which is acceptable overall (for discussion, see Sperber and Wilson 2002; Wilson and Sperber 2002).

A lot of interesting work on communicative development in the last twenty years supports this approach to pragmatics. For instance, there is evidence that pre-verbal infants are heavily engaged in mindreading (a prerequisite to ostensive communication) (Baillargeon et al. 2016); that they are sensitive to certain cues to ostension (Csibra 2010); that they respond differentially to ostensive and non-ostensive acts (Csibra and Gergely 2009; Schulze and Tomasello 2015); and that they form pragmatic

expectations comparable to those of adults (Southgate, Chevallier, and Csibra 2009). On the production side, there is evidence that infant pointing is used not only to inform or to request, but also to share emotions and attitudes, thus providing social or relational information (Tomasello, Carpenter, and Liszkowski 2007); and that young children are adept at using lexical innovations as clues to their intentions in order to fill vocabulary gaps (Falkum, Recasens, and Clark 2017).

As noted above, a major task for pragmatic theory is to describe the pragmatic expectations raised by ostensive acts and explain how they arise. Sperber and Wilson introduce a technical concept of *relevance*, defined in terms of *cognitive effects* and *processing effort,* which they see as central not only to pragmatics, but to cognition more generally. They propose two principles of relevance: a cognitive principle (that human cognition tends to be geared to the maximization of relevance) and a communicative principle (that ostensive acts raise specific expectations of relevance not raised by other stimuli), and argue that the pragmatic expectations that drive the comprehension heuristic are expectations of relevance (see for instance Sperber and Wilson 2002; Wilson and Sperber 2002; Wilson 2017, 2019). The claim that ostensive communication is guided by expectations of relevance rather than expectations raised by, say, Grice's Cooperative Principle and maxims is precise enough to make testable predictions, and many of these predictions have been confirmed (see Van der Henst, Carles, and Sperber 2002; Van der Henst and Sperber 2004; Noveck and Sperber 2007). More generally, this approach to pragmatics has inspired an interesting body of research on a type of communication which is arguably unique to humans and which is likely to provide valuable insights into language use.

27.5 Conclusion

Chomsky's legacy for pragmatics comes mainly from his foundational contribution to cognitive science (reviewed in Section 27.2), along with his view of the mind as a collection of "mental organs" and his work on grammar, which reveals a great deal about one of the major inputs to pragmatic processing (see Ariel 2008).

In a relatively new field such as pragmatics, every avenue is worth exploring. However, it seems to us that Chomsky's conception of pragmatics as the study of language use, and his view of the communicative use of language as just one among many possible uses, led him to miss the significance of Grice's work as pointing towards a new notion of communication as something which can take place independently of language but is vastly enriched when combined with language use.

There have been two major breakthroughs in pragmatics in Chomsky's lifetime. The first was the separation of pragmatics from semantics along broadly Gricean lines; this was at least partly inspired by Chomsky's distinction between competence and performance. The second was the recognition that pragmatics contributes much more to the truth-conditional content of utterances than is still acknowledged in much of semantics. While this second breakthrough is compatible with Chomsky's longstanding skepticism about a truth-conditional semantics for natural language sentences, it came about largely independently of his work, as pragmatic theorists explored the idea that pragmatic principles may guide disambiguation, lexical modulation, pragmatic enrichment and more (Wilson and Sperber 1981; Sperber and Wilson 1986; Carston 1988, 1993; Recanati 1989; for an overview see Carston 2002). A third important

development is currently under way with the investigation of ostensive communication in infants (see Section 27.4); and there is room for many more.

Endnotes

1 We would like to thank Terje Lohndal, Georges Rey, Neil Smith, and Dan Sperber for their very helpful comments on a draft of this chapter.
2 Grice's term was "utterer's meaning," where an "utterance" is an overtly intentional attempt – whether verbal or nonverbal – to produce a certain cognitive or behavioural response in an audience.
3 On the development of Chomsky's views on pragmatics, see Kasher (1991, p. 123). For discussion of Chomsky's notion of pragmatic competence, see Ifantidou (2014, pp. 2–3).
4 In this respect, Chomsky's notion of pragmatic competence is similar to Dell Hymes's well-known notion of 'communicative competence' (Hymes 1974, p. 75).
5 See Glanzberg (Chapter 26 of this volume) and Collins (2017a; 2017b) for further discussion of Chomsky's views on word meaning.
6 Here Chomsky is commenting on Davidson 1986, and agreeing with his skepticism about a theory of interpretation. For discussion, see Allott 2019, p. 34.
7 Their formulation is similar to later Chomsky: "a complete theory of this kind is not possible in principle; for to satisfy the above necessary condition it would be required that the theory represent ALL the knowledge speakers have about the world" (Katz and Fodor 1963, p. 178).
8 On this view, linguistic semantics is the study of aspects of meaning that do not depend on context. Combining this with the now widely-shared but still controversial view that the vast majority (at least) of sentences don't encode propositions suggests that the encoded meaning of a sentence must in general be something like a framework for constructing a proposition, or a constraint on the truth-conditional content of literal utterances of that sentence.
9 Grice equated speaker's meaning with what he earlier called "non-natural meaning" (meaning_{NN}) in contrast with "natural" meaning," as in "Clouds mean rain" (Grice 1957; Neale 1992).
10 On the development of relevance theory, see Sperber (2019).
11 As far as we are aware, no alternative has been proposed, except for the skeptical view that there is no one underlying process.
12 More sophisticated strategies will in general be needed to interpret utterances where the speaker is less than competent or intentionally misleading. (Sperber 1994; Mazzarella and Pouscoulous 2020).

References

Allott, N. 2008. Pragmatics and rationality. PhD thesis, *University of London*.

Allott, N. 2018. Conversational implicature. In *Oxford Research Encyclopedia of Linguistics* [Online encyclopedia], edited by M. Aronoff. Oxford: Oxford University Press. doi: 10.1093/acrefore/9780199384655.013.205

Allott, N. 2019. Scientific tractability and relevance theory. In *Relevance: Pragmatics and Interpretation*, edited by K. Scott, R. Carston, and B. Clark, 29–41. Cambridge: Cambridge University Press.

Ariel, M. 2008. *Pragmatics and Grammar*. Cambridge: Cambridge University Press.

Ariel, M. 2010. *Defining Pragmatics*. Cambridge: Cambridge University Press.

Baillargeon, R., R. Scott, and L. Bian. 2016. Psychological reasoning in infancy. *Annual Review of Psychology* 67 (1): 159–86.

Brown, P., and S. Levinson. 1987. *Politeness: Some Universals in Language Usage*. Cambridge: Cambridge University Press.

Carston, R. 1988. Implicature, explicature and truth-theoretic semantics. In *Mental Representations: The Interface Between Language and Reality*, edited by R. Kempson, 155–181. Cambridge: Cambridge University Press.

Carston, R. 1993. Conjunction, explanation and relevance. *Lingua* 90: 27–48.

Carston, R. 1997. Enrichment and loosening: Complementary processes in deriving the proposition expressed? *Linguistische Berichte* 8: 103–27.

Carston, R. 2000. The relationship between generative grammar and (relevance-theoretic) pragmatics. *Language and Communication* 20: 87–103.

Carston, R. 2002. *Thoughts and Utterances: The Pragmatics of Explicit Communication*. Oxford: Wiley-Blackwell.

Chomsky, N. 1962. Explanatory models in linguistics. In *Logic, Methodology, and the Philosophy of Science*, edited by E. Nagel, P. Suppes, and A. Tarski, 528–550. Stanford: Stanford University Press.

Chomsky, N. 1964. Current issues in linguistic theory. In *The Structure of Language; Readings in the Philosophy of Language*, edited by J. A. Fodor, and J. J. Katz, 50–118. Englewood Cliffs, N.J: Prentice-Hall.

Chomsky, N. 1965. *Aspects of the Theory of Syntax*. Cambridge: MIT Press.

Chomsky, N. 1966. *Cartesian Linguistics*. New York: Harper & Row.

Chomsky, N. 1972. *Language and Mind*. New York: Harcourt Brace Jovanovich.

Chomsky, N. 1974. [Untitled interview]. In *Discussing Language*, edited by H. Parret, 27–54. The Hague: Mouton.

Chomsky, N. 1975. *Reflections on Language*. New York: Pantheon Books.

Chomsky, N. 1980. *Rules and Representations*. New York: Columbia University Press.

Chomsky, N. 1984. On language and culture: Noam Chomsky interviewed by Wiktor Osiatynski. In *Contrasts: Soviet and American Thinkers Discuss the Future*, edited by W. Osiatynski, 95–101. New York: Macmillan. Accessed at https://chomsky.info/1984____/

Chomsky, N. 1991. Linguistics and cognitive science: Problems and mysteries. In *The Chomskyan Turn*, edited by A. Kasher, 26–55. Oxford: Basil Blackwell.

Chomsky, N. 1992a. Explaining language use. *Philosophical Topics* 20: 205–231.

Chomsky, N. 1992b. Language and interpretation: Philosophical reflections and empirical enquiry. In *Inference, Explanation, and Other Frustrations: Essays in the Philosophy of Science*, edited by J. Earman, 99–128. Berkeley: University of California Press.

Chomsky, N. 1995. Language and nature. *Mind* 104 (413): 1–61.

Chomsky, N. 1996. *Powers and Prospects: Reflections on Human Nature and the Social Order*. London: Pluto.

Chomsky, N. 2003. Reply to Horwich. In *Chomsky and his Critics*, edited by L. Antony and N. Hornstein, 295–304. Malden, MA: Blackwell.

Chomsky, N. 2010. The mysteries of nature: How deeply hidden? In *Chomsky Notebook*, edited by J. Bricmont, and J. Franck, 3–33. New York: Columbia University Press.

Collins, J. 2017a. The copredication argument. *Inquiry* 60 (7): 675–702.

Collins, J. 2017b. The semantics and ontology of *The Average American*. *Journal of Semantics* 34 (3): 373–405.

Csibra, G. 2010. Recognizing communicative intentions in infancy. *Mind and Language* 25 (2): 141–168.

Csibra, G., and G. Gergely. 2009. Natural pedagogy. *Trends in Cognitive Sciences* 13 (4): 148–153.

Davidson, D. 1986. A nice derangement of epitaphs. In *The Essential Davidson*, 251–265. Oxford : Clarendon Press.

Falkum, I., M. Recasens, and E. Clark. 2017. "The moustache sits down first": On the acquisition of metonymy. *Child Development* 44 (1): 87–119.

Fodor, J. A. 1983. *The Modularity of Mind: An Essay on Faculty Psychology*. Cambridge: MIT Press.

Grice, H. P. 1957. Meaning. *Philosophical Review 66: 377–388*. Reprinted in Grice, H. P. 1989.

Grice, H. P. 1967. Logic and Conversation. William James Lectures (Harvard University). Reprinted in Grice, H. P. 1989.

Grice, H. P. 1969. Utterer's Meaning and Intentions. *The Philosophical Review 78 (2)*: 147–77. Reprinted in Grice, H. P. 1989.

Grice, H. P. 1975. Logic and conversation. In *Syntax & Semantics 3: Speech Acts*, edited by Peter Cole, and Jerry Morgan, 41–58. New York: Academic Press. Reprinted in Grice, H. P. 1989.

Grice, H. P. 1978. Further notes on logic and conversation. In *Pragmatics*, edited by Peter Cole, 113–27. New York: Academic Press. Reprinted in Grice, H. P. 1989.

Grice, H. P. 1989. *Studies in the Way of Words*. Cambridge, MA: Harvard University Press.

Horn, L., and G. Ward, eds. 2004. *The Handbook of Pragmatics*. Oxford: Blackwell.

Huang, Y. (ed.) 2017. *The Oxford Handbook of Pragmatics*. Oxford: Oxford University Press.

Hymes, D. H. 1974. *Foundations in Sociolinguistics: an Ethnographic Approach*. Philadelphia: University of Pennsylvania Press.

Ifantidou, E. 2014. *Pragmatic Competence and Relevance*. Amsterdam: John Benjamins.

Kasher, A. 1991. Pragmatics and Chomsky's research program. In *The Chomskyan Turn*, edited by A. Kasher, 122–49. Oxford: Basil Blackwell.

Katz, J. J., and J. A. Fodor. 1963. The structure of a semantic theory. *Language* 39(2): 170–210.

Levinson, S. C. 2000. *Presumptive Meanings: The Theory of Generalized Conversational Implicature*. Cambridge: MIT Press.

Mazzarella, D., and N. Pouscoulous. 2020. Pragmatics and epistemic vigilance: A developmental perspective. *Mind & Language* (online early view).

Neale, S. 1992. Paul Grice and the philosophy of language. *Linguistics and Philosophy* 15 (5): 509–559.

Noveck, I., and D. Sperber. 2007. The why and how of experimental pragmatics: The case of 'scalar inferences'. In *Pragmatics,* edited by N. Burton-Roberts, 184–212. Basingstoke: Palgrave-Macmillan.

Pollard, A. 2015. The speech disorganizers: Uncooperative addressees and their impact on speakers. *Intercultural Pragmatics* 12 (2): 139–160.

Recanati, F. 1989. The pragmatics of what is said. *Mind and Language* 4: 295–329.

Recanati, F. 2004. *Literal Meaning*. Cambridge: Cambridge University Press.

Recanati, F. 2010. *Truth-Conditional Pragmatics*. Oxford: Clarendon Press.

Schiffrin, D. 1994. *Approaches to Discourse*. Oxford: Blackwell.

Schulze, C., and M. Tomasello. 2015. 18-month-olds comprehend indirect communicative acts. *Cognition* 136: 91–98.

Scott-Phillips, T. 2014. *Speaking Our Minds: Why Human Communication Is Different, and How Language Evolved to Make it Special*. Basingstoke: Palgrave-Macmillan.

Southgate, V., C. Chevallier, and G. Csibra. 2009. Sensitivity to communicative relevance tells young children what to imitate. *Developmental Science* 12(6): 1013–1019.

Sperber, D. 1994. Understanding verbal understanding. In *What is Intelligence?*, edited by J. Khalfa, 179–98. Cambridge: Cambridge University Press.

Sperber, D. 2019. Personal notes on a shared trajectory. In *Relevance, Pragmatics and Interpretation*, edited by K. Scott, B. Clark and R. Carston, 13–20. Cambridge: Cambridge University Press.

Sperber, D., and D. Wilson. 1986/1995. *Relevance: Communication and Cognition*. (2nd ed. 1995). Oxford: Blackwell.

Sperber, D., and D. Wilson. 1996. Fodor's frame problem and relevance theory: Reply to Chiappe and Kukla. *Behavioral and Brain Sciences* 19(3): 530–532.

Sperber, D., and D. Wilson. 1997. Remarks on relevance theory and the social sciences. *Multilingua* 16: 145–151.

Sperber, D., and D. Wilson. 1998. The mapping between the mental and the public lexicon. In *Language and Thought: Interdisciplinary Themes,* edited by J. Boucher and P. Carruthers. Cambridge: Cambridge University Press.

Sperber, D., and D. Wilson. 2002. Pragmatics, modularity and mind-reading. *Mind and Language* 17 (1&2): 3–23.

Sperber, D., and D. Wilson. 2008. A deflationary account of metaphors. In *The Cambridge Handbook of Metaphor and Thought,* edited by R. Gibbs. Cambridge: Cambridge University Press.

Sperber, D., and D. Wilson. 2015. Beyond speaker's meaning. *Croatian Journal of Philosophy XV* (44): 117–149.

Stemmer, B. 1999. An on-line interview with Noam Chomsky: On the nature of pragmatics and related issues. *Brain and Language* 68 (3): 393–401.

Taylor, T., and D. Cameron. 1987. *Analyzing Conversation*. New York: Pergamon Press.

Todd, P. M., and G. Gigerenzer. 2000. Précis of 'Simple Heuristics that Make us Smart.' *Behavioral and Brain Sciences* 23 (5): 727–741; discussion 742.

Tomasello, M., M. Carpenter, and U. Liszkowski. 2007. A new look at infant pointing. *Child Development* 78 (3): 705–722.

Van der Henst, J.-B., L. Carles, and D. Sperber. 2002. Truthfulness and relevance in telling the time. *Mind and Language* 17 (5): 457–466.

Van der Henst, J.-B., and D. Sperber. 2004. Testing the cognitive and communicative principles of relevance. In *Experimental Pragmatics,* edited by I. Noveck and D. Sperber, 141–171. Basingstoke: Palgrave-Macmillan.

Vriend, N. J. 1996. Rational behavior and economic theory. *Journal of Economic Behavior and Organization* 29 (2): 263–285.

Wharton, T. 2009. *Pragmatics and Non-Verbal Communication*. Cambridge: Cambridge University Press.

Wilson, D. 2017. Relevance theory. In *The Oxford Handbook of Pragmatics*, edited by Y. Huang, 79–100. Oxford: Oxford University Press.

Wilson, D. 2019. Relevance theory. In *Oxford Research Encyclopedia of Linguistics* [Online encyclopaedia], edited by M. Aronoff, Oxford: Oxford University Press. doi: 10.1093/acrefore/9780199384655.013.201

Wilson, D., and R. Carston. 2007. A unitary approach to lexical pragmatics: Relevance, inference and ad hoc concepts. In *Pragmatics,* edited by N. Burton-Roberts. Basingstoke: Palgrave.

Wilson, D., and D. Sperber. 1981. On Grice's theory of conversation. In *Conversation and Discourse: Structure and Interpretation*, edited by P. Werth, 155–178. London: Croom Helm.

Wilson, D., and D. Sperber. 2002. Truthfulness and relevance. *Mind* 111: 583–632.

Wilson, D., and D. Sperber. 2012. *Meaning and Relevance*. Cambridge: Cambridge University Press.

Part VI

Cognitive Science and Philosophy of Mind

28

Nativism

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28.1 Introduction

A central claim of Chomsky's theory of grammar is that the underlying principles of grammar are innate: aside from learning the pronunciation of basic lexical items and possibly setting parameters along which specific grammars can vary, children are essentially born with a computational system, an I-language, that is governed by principles of Universal Grammar (UG).[1] It's a specific computational system somehow realized in the brain that seems (as a whole) peculiar to language and permits children quickly and effortlessly to acquire a linguistic competence very like that of speakers in their community.

Chomsky (1965, 1966, 1968/2006) early on associated this hypothesis with views of the traditional "Rationalists," such as Plato, Descartes, and Leibniz, who argued that many of our ideas especially about logic, geometry, and mathematics, were innate. These views were resisted by the English empiricists such as Locke, Berkeley, and Hume, according to whom all our ideas were "derived from experience": sensory impressions of experience provided a basis for ideas that were formed either as faint copies of them, or by a process of association, whereby "complex" ideas could be formed that could apply beyond experience. With the development of formal logic in the twentieth century, "logical empiricists/Positivists" allowed logical complexes of experience that were verified or falsified by it. It was widely assumed that people's understanding of language could be understood along these lines.

In order to avoid problems associated with the mentalistic ways of understanding this traditional view, many Twentieth-Century empiricists adopted a *scientific behaviorism,* whereby the relevant associations were not between what was feared to be hopelessly "private" experience, but between stimuli, responses, and reinforcements, a view Skinner (1957) specifically proposed for the case of language (see also Bloomfield, 1933). As is well-known, this conception was subject to a devastating critique

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by Chomsky (1959/1964). He argued that Skinner's (1957) proposals couldn't begin to explain the specific, abstract rule systems of human languages, much less how all human children could acquire them with such speed and little effort, particularly given what he noted to be the lack of sufficient data and reinforcements in their early experience.

This last point is his celebrated "poverty of the stimulus" argument, and the substantial empirical evidence it involves is discussed in articles in Part IV of this volume. Striking examples the reader might keep in mind that make the point are provided by what Chomsky (2013:41) calls "(perfectly) fine thoughts," what might more perspicuously be called "WhyNots": strings of words such as ("*" indicates non-acceptability):

**Who will John and kiss Mary?*
(cf. *John and* <u>*who*</u> *will kiss Mary?)*

whose intended meaning could be easily ascertained in context, but which virtually all English speakers would find unacceptable. In fact, *no* human language permits *wh*-extraction of a single conjunct from a conjunction,[2] and the question is, *why not*? If it were a mere social convention picked up from experience, one would expect at least some variation, or at least some ease in changing it. In any case, how could young children possibly learn about it from their relatively meager and usually grammatically untutored experience?

This chapter will be concerned only with some of the conceptual (or philosophical) issues relevant to the innateness hypothesis: the supposed analogy with Rationalists' concern with mathematics (Section 28.2); the false contrast between innate and learned (Section 28.3); and the character of general statistical (GenStat) approaches (Section 28.4). These latter approaches initially face Goodman's problem of confining generalizations to "projectible" as opposed to arbitrary predicates (Section 28.4.1); but a Bayesian model can limit the predicates to only those in hypotheses with high "prior" probabilities, which in the case of a neonate would amount to merely a "predicate" nativism (Section 28.4.2). It is not so easy, however, to deal with a Leibnizian problem of the modal status of grammatical rules (Section 28.4.3), nor with a little-noticed problem, ironically enough raised by the modern empiricist Quine, what I call *superficialism* regarding the data available to the child (Section 28.5). We'll see that a consideration of these problems will invite a specific form of nativism, what might be called a "quasi-brute process" nativism, that is actually not as closely related to traditional Rationalism as Chomsky originally proposed, but is what he and others have arguably had in mind since the development of the Principles and Parameters (P&P) and other "biological" models beginning in the 1970s (see Sheehan, Chapter 11). If this is right, then it provides a radical alternative to any form of mere GenStatism, that would rely on statistical regularities in experience alone.

28.2 Plato's Problem, or Brute Biology?

Chomsky has over the years provided some misleading arguments for an innate UG, and it's important to set them aside so the best ones can shine out. The most bewildering is his characterization of the denial of UG as somehow committed to there being "no difference

between my granddaughter, a rock and a rabbit" (2000: 50). Obviously, no one holds such a silly view: rocks have no mental life at all, and even the most extreme empiricist could propose ways to distinguish human from rabbit minds in a variety of ways. Chomsky's hyperbolically expressed point is that the substantive issues of nativism lie in specifying the differences between the "native" endowment of these different things.

Chomsky often calls the difficulty of language acquisition an instance of Plato's problem, assimilating it to a problem famously raised by Plato in his "Meno," in which Socrates engages in a dialogue with an untutored slave boy, who (with a little prodding) seems to come to enunciate a non-obvious theorem of geometry apparently by reasoning alone. Plato thought what the boy was doing was recollecting knowledge from a previous lifetime; later Rationalists, such as Descartes (1637/1984) and Leibniz (1704/1981) claimed that such apparently *a priori* knowledge people seem to have of geometry and mathematics was innate.[3] A comparison of a grasp of grammar with a grasp of logic and geometry is, however, not entirely felicitous. The problem of language acquisition is much more peculiar than that raised by apparently *a priori* knowledge: for all the (rather meager) evidence that Plato provides in the "Meno," it could easily be the case that the boy comes to appreciate a theorem in geometry simply by applying innate general strategies of "pure reason" to spatial concepts. But this would obviously not be a model for knowledge of grammar. No one has proposed that the principles of grammar are "truths of reason," knowable *a priori,* in the way that the Rationalists regarded knowledge of mathematics and geometry.

At the opposite extreme of comparing language acquisition to a rational process such as reflection on geometry, Chomsky often compares it with brute processes of maturation, like the growth of bodily organs. He sometimes overstates this case, claiming it would be irrational for anyone to disagree (see Chomsky and McGilvray, 2012: 123). But a nativist suggestion is plainly not equally true of *every* human mental capacity. There is a spectrum between capacities whose explanation is largely grounded internally in human beings and those whose explanation is grounded more in their external history. At one extreme are sensitivities to color and pain, which seem largely innate, subject only to fine-tuning by cultural experience; at the other end are abilities to play chess, learn history, and engage in various social institutions such as democracy or a market. Other than requiring language and general human intelligence, these latter seem mostly grounded in people's specific interactions with each other in external environments. In between these extremes are phenomena, such as musical, artistic, and literary prowess that are likely grounded in both. With its (all hands agree) largely arbitrary selection of phonological forms as morphemes, and (for Chomskyans) its settings of biologically determined parameters, language is somewhere in this complex area intermediate area. In any case, it's surely not irrational to think that language acquisition may be in many significant respects empirically based in a way that the growth of teeth is not.

As many have observed, the term *innate* is actually not a happy one, being notoriously difficult to characterize across biological domains.[4] In this chapter, it will suffice to rely on a notion relatively specific to cognitive abilities, that of a species-wide *initial state* of a system that develops into fairly *stable states* as a result of input to the system. Chomsky's core claim is that, in the case of grammar, that initial state is UG, a biological endowment that begins to become available sometime around birth, and serves as the basis for responding to the input in such a way that shortly brings about the a stable state of competence with ambient language(s). The task of what he (1965) regards as

an "explanatorily adequate" linguistic theory is to characterize that initial and final state, and the intensional function (or way of computing the function) that takes the child from one to the other under the influence of experience.

28.3 Innate *and* Learned!

A misleading feature of much of the discussion in Chomsky and in many of both his followers and detractors, is the *contrast* often drawn between the innate and the learned along fairly coarse lines, where, say, a capacity to form beliefs might be innate, but the formation of a specific belief, say, that cats meow, is likely gained by making associations or logical constructions from sense experience in the way empiricists proposed.

Associationism and logical construction are, however, not the only learning mechanism an empiricist need propose. Indeed, as Fodor (1975: 34ff) pointed out, a standard modern empiricist model of concept acquisition involves a form of hypothesis confirmation, determining which concept might best fit the data. Interestingly, this is precisely the conception Chomsky (1965) initially advanced as a model of language acquisition. In a well-known passage, he wrote:

> Let us consider with somewhat greater care just what is involved in the construction of an "acquisition model" for language. A child who is capable of language must have
>
> (i) a technique for representing input signals;
> (ii) a way of representing the structural information about these signals;
> (iii) some initial delimitation of a class of possible hypotheses about language structure;
> (iv) a method for determining what each such hypothesis implies with respect to each sentence;
> (v) a method for selecting one of the (presumably, infinitely many) hypotheses that are allowed by (iii) and are compatible with the given primary linguistic data. Chomsky (1965: 30)

What's particularly striking about this proposal is that it is virtually identical to the standard "Deductive-Nomological" (D–N) model of empirical hypothesis confirmation in science proposed at roughly the same time by Carl Hempel (1962),[5] as well as the model of concept learning Fodor takes to be routine in psychology. So Chomsky's model would actually seem to be a *learning* model. Indeed, Chomsky (1968/2006) made an explicit comparison of language acquisition with Peircean abduction in science, according to which our significant theories of any domain involve what has come to called "an inference to the best explanation," the range of acceptable explanations being highly constrained from birth. It is doubtless such a model that led Jim Higginbotham (1991: 556) to insist that language acquisition is "a rational achievement." Yet Higginbotham, like Chomsky, nonetheless regards UG as innate. Consequently, the manifested grammar on this view so far is both innate *and* learned: it is possessed innately as among the candidate grammars, but then one of its candidates is selected (i.e. learned on the basis of experience). Thus, you can learn what you already possess!

What I think Chomsky really intends to rule out by appeal to nativism is not *learning* a grammar from sense experience, but rather *constructing* it from such experience in the way that empiricists had typically claimed for all our ideas. Our grammars, like our ideas of most things, are very likely not mere associations or even logical constructions from sense impressions, but they may be *learned* nonetheless. One might usefully think of the set of grammars that are innately possessed as being just that set that can come

to be acquired by learning on the basis of exposure to certain sorts of input. As Leibniz (1704/1981) noted with regard to his own strong nativist claims:

> I quite agree that we learn innate ideas and innate truths, whether by paying heed to their source or by verifying them through experience. So I do not suppose, as you say I do, that in the case you have mentioned we learned nothing new. And I can't accept the proposition that whatever is learned is not innate. The truths about numbers are in us; but still we learn them, whether by drawing them from their source, in which case one learns them through demonstrative reason (which shows that they are innate), or by testing them with examples, as common arithmeticians do. – Leibniz (1704/1981:bk I,i,23)[6]

Rather than being opposites, at least linguistic innateness and learning are dependent upon one another, part and parcel of a creature's cognitive system. As Jeff Lidz and Annie Gagliardi (2015) observe:

> The presence of UG does not remove the need of a learning theory that explains the relation between the input and the acquired grammar.
> – Lidz and Gagliardi (2015:12–13, see also Yang, 2003:451)

However, as will become increasingly vivid when we consider the constraints language acquisition imposes, we'll see that what's really at issue in Chomsky's theory is not nativism vs. statistical learning *tout court*, but whether language is constrained in a highly *domain-specific way* that renders it crucially different from acquisition of knowledge in other domains. We'll see that there are a series of increasingly severe constraints that limit the utility of general learning strategies, and ultimately seem to distinguish the nativism required for language from the nativisms that might be required for general cognition.

28.4 Statistical Approaches

The statistical approach that might first come to mind is simple induction, or generalizing about an entire class on the basis of some sample of it. If *n*% of observed nouns are followed by verbs, then conclude that *n*% of all nouns are followed by verbs. This is one way one might understand GenStat approaches. Such simple induction, however, was shown to be subject to a serious problem noticed by Chomsky's mentor, Nelson Goodman.

28.4.1 Goodman's Problem of "Grue" (Projection Nativism)

Goodman (1955/83), provided an interesting new twist to the familiar problem of induction first noticed by David Hume, who wondered what justified our making simple inductive inferences from examined to unexamined cases, as we do in predicting that the sun will rise. Goodman pointed out that there was an infinitude of possible *concepts* that could be "projected" from any examined to unexamined data. For those who haven't heard his famous *grue* problem: Consider all the emeralds that have ever been examined. All of them have been examined before some time *t*, let's say, 3000 AD, and

have been found to be green. But, if so, then they all also satisfy all of the infinitude of following predicates:

x is grue_{3000}: *x* is green and examined before 3000 AD or otherwise blue.
x is grue_{3001}: *x* is green and examined before 3001 AD or otherwise blue.
x is grue_{3002}: *x* " " " 3002 AD " " " .
… etc.

The point is, of course, not confined to perceptual predicates like *green*. For any predicate, we can define an analogous infinite supply of unnatural, "*grue-some*" predicates: *emerose* (an emerald until 3000 AD or a rose), *electrino* (electron until 3000 AD or a neutrino), or, in the case of grammar, *nounverb:* a noun until 3000 AD or a verb. What rules out such grue-some predicates and hypotheses?[7]

It bears stressing (because it's so persistently ignored) that a failure to address this problem vitiates appeals to mere "analogy," "abstraction," and "generalization" of the sort Chomsky criticized in Skinner, and one could equally criticize in more recent, non-behaviorist but still non-Chomskyan proposals about acquisition, as in Goldberg (1995, 2003) and Tomasello (2005: pp. 189, 193–194). *Everything* is similar and analogous to *everything* else in *some* respect, if only by the fact that any two things belong to an infinitude of sets. For example, trees and the number 3 belong to the sets, {trees, 3} and {things mentioned in this book}; emeralds observed before 3000 AD and sapphires observed thereafter to the set of things that are grue_{3000}. The explanatory work to be performed by analogy, abstraction, and generalization depends entirely on just *which* sets and/or predicates ought to be analogized, abstracted, and used as bases for generalization. Specifying the *relevant* respects for such linguistic understanding is what a serious psycholinguistic theory is about.[8]

28.4.2 Bayesianism and "Predicate Nativism"

Sophisticated statistical approaches to language acquisition usually do acknowledge that any statistical inductions have to be made against a background of quite specific natural predicates.[9] Indeed, much recent work employs *Bayesian inferences*, based on Bayes's well-known theorem in probability theory, whereby the probability of a hypothesis is a function of

(i) the prior probabilities of it and its alternatives;
(ii) the probability of the evidence by itself;
(iii) how probable it renders that evidence (the hypothesis's "likelihood").

Thus, for example, the probability that a certain grammatical principle is correct would depend on its prior probability, the probability of the evidence one has received, and how probable that principle would render that evidence (see Pearl, Chapter 17, for discussion and examples). In the case of language acquisition by a neonate, higher "prior" probabilities of certain hypotheses employing only certain predicates may be what is innately specified, thus avoiding at least humanly *grue*-some ones, but including the predicates for the various linguistic categories. So GenStatists, along with anyone who's noticed the *grue* problem, can be what we might call "predicate nativists." This would be one natural way of reading Chomsky's (1965) hypothesis testing proposal quoted earlier (which may well have been what invited GenStatism in the first place!).[10]

There are, however, further problems to be faced.

28.4.3 Modal Nativism

As Leibniz and (later) Kant famously pointed out, "modal" claims regarding what's *(im)possible*, or what *can't* or *must* happen can't be established merely on the basis of the statistics of experience alone. Merely regularly experiencing that pairs of pairs are quadruples doesn't show that 2 + 2 *must* be 4. Of course, rules of grammar don't have the status of the kinds of laws of "reason" that Leibniz and Kant had in mind. WhyNots, for example, indicate what "can't" be said in a quite restricted sense, and only, at best, for creatures with the same I-language. It's striking that we can easily imagine a language that *did* allow many of the WhyNots; it just wouldn't be a human one. But the point about modality remains: Could any mere enumeration of speech instances ever establish what "can't" be said, e.g. **Who did Bill and kiss Mary?*, as opposed to merely what hasn't been – or in fact has been, but in violation of the rules?

Note that it's not enough never to have *encountered* an utterance of a WhyNot. There is a potential infinity of grammatical utterances children haven't heard: 500 conjunctions of *Snow is white*, sentences from Hegel or Proust, or semantic nonsense, such as Chomsky's famous *Colorless green ideas sleep furiously*, or absurdities like *Humans are kangeroos*. Moreover, they may often hear ungrammatical strings, as when they hear deliberate "nonsense" (*Twas brillig …),* or when people speak elliptically (*Raining yet? Turns out he's thief*; cf., Fromkin, 1980). The problem is that rules of grammar are only obliquely related to probability distributions of utterances. When people have unacceptability responses to WhyNots, this is usually not a matter of their making an estimate of how *likely* or *unlikely* it is that such a string may be produced. They are simply manifesting their competence: there's something about the structure of the string that makes it peculiarly hard, and often *impossible* to process. It's these peculiar modal constraints on language that it's hard to see a non-generativist theory explaining.

Of course, a GenStatist could claim that if the probabilities of certain hypotheses were set to 0, they might be treated as impossible. This would be tantamount to treating them as logical contradictions, which at least many of them clearly are not. But perhaps the difficulty we have with them is like the difficulty we have in thinking a contradiction –only worse, since contradictions are at least *grammatical.* In any case, it would be good to have an explanation of why these and not other hypotheses are treated this way. Why *shouldn't* a grammar allow **Who did John and kiss Mary?* and other perfectly comprehensible strings? The difficulties don't seem to arise merely from the content of hypotheses about grammar, but in something more *architectural* about the mind.[11]

This points to what I think is the deepest difficulty for a GenStat approach.

28.5 Quine's Problem of Superficialism and a Solution

Despite his endorsement of the view, Quine (1960/2013) was admirable in appreciating some of Behaviorism's surprising consequences. He showed it raised a problem of how to distinguish claims about linguistic meaning from claims about the world without appealing to psychological distinctions that are behavioristically obscure. What he didn't stress is how the problem generalizes to *all* the main categories of language: How can we possibly distinguish what's part of a language's syntax or even its phonology without some hypotheses about the underlying systems responsible for them? Perhaps a sentence presents merely computational difficulties (as in the case of center embeddings, such as *The man the cat the dog chased scratched died).* This issue doesn't depend on the

specific commitments of scientific behaviorism, but would arise for any view that would confine itself merely to phenomena at the surface of our psychological lives, e.g. views like those the later Wittgenstein (1953/2016) that would claim that "an inner process stands in need of an outward criterion" (Section 580), which can be generally characterized as *superficialist*. The problem is that, apart from the structure of human psychology, it is simply not determinate that *there is even such a thing as grammar*, much less what the specifics of it are.

The specific problem this raises for GenStatists is how an infant is to *conceptualize* the "grammar" these algorithms are supposed to learn. As the prevalence of solecisms like *Raining yet?* and the absence of billion-word utterances show, it can't simply be a matter of ordinary speech conventions and regularities. Whether the speech a child hears is a reliable indicator of *grammar* would depend on whether the child's best explanation of it is due to in fact to human grammatical competence – captured, let us suppose, by UG – or, instead, to shared pragmatics: belief, style, speech efficiency; or by features of computability and short-term memory. But how are *children* supposed to know even to be on the lookout for all these distinctions? Even if an innate, modally constrained grammar is a specific theory that children are innately disposed to entertain, why should mere regularities in the input be evidence of *it*, rather than just evidence merely of patterns in *the noises* people make?

What would seem to be required for serious, rational language acquisition would not be mere extraction of regularities in people's *noises*, but *hypotheses about the structure of their psychology*, precisely of the sort Chomskyan linguists are attempting to provide. A mere statistical inference on the basis of repeated speech patterns won't be adequate: what one needs is a full *abduction*, or inference to the best explanation of whatever data are available about the underlying structure of the human mind, i.e., the hypotheses that are simplest, most general, most integrated with whatever else we know about the mind. This is an inference that would require a great deal more than the observations even highly intelligent children might make of the speech and other behavior with which they are presented.

Alternatively, along the lines of the P&P model, the *language faculty* may operate as a fairly autonomous mechanical system, *governed* by principles that are as built into the brain as the principles of the immune system are built into the body, but not *represented* as *hypotheses* in it. Consequently, the child doesn't come to adhere to them by way of any process of inference or confirmation, any more than the immune system confirms the principles that it obeys.[12] This might be called a "quasi-brute process nativism": the *principles* govern a brute, non-representational causal process, but one that might well be mediated by representations of whatever *parameters* are likely set by statistical inferences from heard speech (hence the "quasi-"). Even if children are generally employing a "theory of mind" in understanding the people around them, they are in no position to make an inference to the best explanation of enough of the intricacies of speakers' psychology to distinguish the I-language from the various other mental systems with which it interacts (it's hard enough for professional linguists!).

28.6 Conclusion

If this conception of a "process" nativism is correct, then one might say that the GenStatists aren't really addressing the same issues as Chomskyans. Although

the specific morpho-phonemic entries need to be acquired, and the parameters of UG may well be set by statistical inferences based on experience, at least for the child the principles of UG aren't even improbable hypotheses at all. They are simply principles governing the operation of the faculty, neither confirmed nor refuted by experience, but simply occasioned and/or triggered into operation by it. Children don't confirm the principles of grammar any more than they confirm the principles that govern their growth. Such principles explain the operation of systems that are almost entirely innate.[13]

Endnotes

1 As distinct from the "E(xternal)-languages, such as, roughly speaking, "English" or "Mandarin" that people ordinarily take themselves to be speaking ("roughly," since Chomsky doesn't think what people are ordinarily referring to by "languages" is at all clearly defined). See Chomsky (1986) and the introduction to this volume for discussion.

2 See Szabolcsi and Lohndal (2017) for discussion of many such "strong islands," which are found in all known languages.

3 It's important to distinguish the *a priori* from the innate: a claim can be known *a priori* if it is *"justifiable* independently of experience"; it is innate if it is somehow in-born. The two may overlap, but a belief, say, that space is Euclidean might be innate but not knowable *a priori*.

4 See Gross and Rey (2012) for discussion and further references in the philosophy of biology literature.

5 Hempel's proposal goes back the 1950s, and, given that he ran in the same 1950s intellectual circles as Hempel, it's puzzling that Chomsky doesn't note the similarity.

6 I'm indebted to Steven Gross for drawing my attention to this quotation. Interestingly, Chomsky (1965: 50) cites it, but reads it as Leibniz simply refusing to "draw a sharp distinction between innate and learned." But it's not that the distinction is blurry; it's the wrong one to draw!

Chomsky (1966: 62–63) does realize that the activation of innate knowledge typically awaits external stimulation; but the crucial issue is whether this stimulation could be the occasion for *learning* what is activated. The point here is worth emphasizing, since the vociferous nativist Jerry Fodor (1998: Chapter 6) painted himself – and, he claimed, a Chomskyan linguistics – into a corner by missing it, claiming that an item couldn't be both innate and rationally related to the experiences that occasion it.

7 Goodman (1955/83) was, of course, concerned with which predicates we were *justified* in projecting. But the problem can equally be raised with regard to what predicates children *do* project.

8 It's important to notice that an appeal to "natural" concepts or properties will likely be of little help here, unless this just means the concepts and properties with or about which humans think. And what's "natural" for them may not be natural in the world. Indeed, *green* is in fact likely to be idiosyncratic to certain human visual systems, and so is likely to be almost as bad as *grue*.

9 Thus, although they don't explicitly discuss "grue," Saffran (2002: 173), and Lappin and Schieber (2007) at least acknowledge the problem. It is not so much as mentioned in either Tomasello's (2005) or Cowie's (1999, 2008) critiques of Chomsky's nativism.

10 An essentially "grue"-some problem for linguistics is nicely provided by Lasnik and Uriagareka (2002). Note that the problem is even more severe if Fodor (1998) is right and grammatical concepts aren't analyzable into sensory terms: the predicate base will have to involve not merely sensory predicates, but specifically grammatical ones.

11 Pylyshyn (1984) notes that an architectural explanation is almost always preferable to a mere content one.

12 Cowie (2008: Section 2.1) misses this crucial point.

13 Some of this entry is drawn from my (2020: Chapter 5), which readers should consult for fuller treatment.

References

Bloomfield, L. 1933. *Language*, New York: Henry Holt.

Chomsky, N. 1959/64. "A Review of B. F. Skinner's Verbal Behavior," *Language*, 35:26-58. Re-printed in *Readings in the Philosophy of Language* edited by Fodor, J. and Katz, J., pp 547–78. Englewood Cliffs, NJ: Prentice Hall.

Chomsky, N. 1965. *Aspects of the Theory of Syntax*. Cambridge MA: MIT Press.

Chomsky, N. 1966. *Cartesian Linguistics*. New York: Harper and Row.

Chomsky, N. 1968/2006. *Language and Mind*, 3rd ed.. Cambridge: Cambridge University Press.

Chomsky, N. 1986. *Knowledge of Language: Its Nature, Origin and Use*. New York: Praeger.

Chomsky, N. 2000. *The Architecture of Language*, New Delhi: Oxford University Press.

Chomsky, N. 2010. "The Mysteries of Nature: How Deeply Hidden?" *Journal of Philosophy, Cvi* (4): 167-200.

Chomsky, N. 2013. "Problems of Projection," *Lingua*, 130: 33–49.

Chomsky, N. and McGilvray, J. 2012. *The Science of Language: Interviews with James McGilvray*, Cambridge: Cambridge University Press.

Cowie, F. 1999. *What's Within: Nativism Re-Considered*, Oxford: Oxford University Press.

Cowie, F. 2008. "Innateness and Language," at *Stanford Encyclopedia of Philosophy*: on-line at https://plato.stanford.edu/entries/innateness-language/

Goodman, N. 1955/83. *Fact, Fiction and Forecast*. Cambridge: Harvard University Press.

Descartes, R. 1637/1984. "Discourse on the Method," in *The Philosophical Writings of Descartes*, Vol. I, translated and edited by J. Cottingham, R. Stoothoff, and D. Murdoch, pp 111-176. Cambridge: Cambridge University Press.

Fodor, J. A. 1975. *The Language of Thought*. New York: Crowell

Fodor, J. A. 1998. *Concepts: Where Cognitive Science Went Wrong*, Cambridge, MA: MIT Press.

Fromkin (ed.), *Errors in Linguistic Performance: Slips of the Tongue, Ear, Pen, and Hand*. New York: Academic Press.

Goldberg, A. 1995. *Constructions: A Construction Grammar Approach to Argument Structure*, Chicago: University of Chicago Press.

Goldberg. A. 2003. "Constructions: A New Theoretical Approach to Language," *Trends in Cognitive Science*, 7 (5): 219–24.

Goldberg. A. 2003. Constructions: A new theoretical approach to language. *Trends in Cognitive Science* 7 (5): 219–224.

Goodman, N. 1955/83. *Fact, Fiction and Forecast*, 4th ed. Cambridge, MA: Harvard University Press.

Gross, S. and Rey, G. 2012. Innateness. In: *Oxford Handbook of Philosophy of Cognitive Science*, edited by E. Margolis, and S. Laurence, 318–369. Oxford: Oxford University Press.

Hempel, C. 1962. Deductive-Nomological vs. Statistical Explanation. In *Minnesota Studies in the Philosophy of Science*, Vol. III., edited by H. Feigl and G. Maxwell, Minneapolis: University of Minnesota Press, 98–169.

Higginbotham, J. 1991. Remarks on the metaphysics of linguistics. *Language and Philosophy* 14: 555–566.

Lappin, S., and Schieber, S. 2007. Machine learning theory and practice as a source of insight into universal grammar. *Journal of Linguistics* 43: 393–427.

Lasnik, H. and Uriagereka, J. 2002. On the poverty of the challenge. *The Linguistic Review* 19: 147–150.

Leibniz, G. 1704/1981. *New Essays on Human Understanding*, translated by P. Remnant and J. Bennett, Cambridge: Cambridge University Press, 1981.

Lidz, J. and Gagliardi, A. 2015. How nature meets nurture: Universal Grammar and statistical learning. *Annual Review of Linguistics* 1 (1): 12–21.

Quine, W. 1960/2013. *Word and Object*, 2nd ed., ed. Dagfinn Føllesdal, Cambridge: MIT Press.

Skinner, B. 1957. *Verbal Behavior*. Acton, MA: Copley Publishing Group.

Szabolcsi, A., and Lohndal, T. 2017. Strong vs. weak islands. In *The Wiley Blackwell Companion to Syntax (*part of *The Wiley Blackwell Companions to Linguistics)*, 2nd ed., edited by M. Everaert and H. Van Riemsdijk), 1–51; Oxford: Wiley-Blackwell.

Tomasello, M. 2005. *Constructing a Language A Usage-Based Theory of Language Acquisition*, Cambridge, MA: Harvard University Press.

Pylyshyn, Z. 1984. *Computation and Cognition: Towards a Foundation for Cognitive Science*. Cambridge: MIT Press.

Rey, G. forthcoming. *Representation of Language: Philosophical Issue in a Chomskyan Linguistics*. Oxford: Wiley-Blackwell.

Wittgenstein, L. 1953/2016. *Philosophical Investigations*, 4th rev ed., edited and translated by G. E. M Anscombe, P. M. S. Hacker, and J. Schulte. Chichester (UK): John Wiley and Sons Ltd.

Yang, C. 2003. Universal Grammar, statistics or both? *Trends in Cognitive Science* 8 (10): 451–456.

29

The Deep Forces That Shape Language and the Poverty of the Stimulus

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29.1 Introduction

In the *Language of Thought* (1975), Jerry Fodor invites us to consider two different answers to the question, "What makes Wheaties the breakfast of champions?" [Wheaties is a breakfast cereal sold in the U.S.A.] One answer provides a "causal story" – it explains why certain properties contained in Wheaties (vitamins, carbohydrates, wheat germ, …) make champions out of people who eat Wheaties. The other answer offers a "conceptual story" - a significant number of champions eat Wheaties.

Chomsky's theory of Universal Grammar (UG) offers a causal story about the acquisition of language. The theory of UG spells out linguistic principles and parameters that enable typically-developing children to produce and understand language. By age three or four, all typically developing children attain a stable state of linguistic competence that is rich enough in detail to permit them to converse effortlessly with other speakers, as well as to accurately judge the truth and falsity of sentences in different settings. Looking across languages, we see that three- to four-year-old children across the globe have acquired the same abilities with equal ease and without formal instruction. To paraphrase Roger Brown, the development of language in children gives the impression of a biological process, almost as if microscopic language cells were dividing and combining and then redividing and recombining in ways common to the species. This chapter discusses some of the causal forces that enable young children to acquire language. The main point of the chapter is to demonstrate that these causal forces are not readily apparent in the input that children experience. The lack of decisive evidence in children's experience for the casual forces of language makes it highly implausible to suppose that the causal forces of language are learned. Instead, they are attributed to the theory of UG, i.e. the innately specified, initial state of the human faculty for language (Chomsky 1965, 1981, 1988).

Linguists do not attempt to prove that the acquisition of language is the consequence of a specific set of principles, rather than alternative principles. Adopting a term used by the physicist Richard Feynman (1965, pp. 149–173), the principles proposed by

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theoretical linguists are "guesses" about the causal forces of language. Guesses range from vague, untestable hypotheses to definite theories or "real guesses" about the causal forces of language. We will show how a real guess, i.e. a definite theory, is formulated by linguists, based on evidence both within and across languages. The success of any real guess is measured by the usual scientific criteria: simplicity, parsimony, empirical coverage, and the power to make verifiable predictions.

In several cases, the causal forces proposed by linguists have been subsequently verified by experimental research in child language (Crain and Thornton, this volume, review extensive empirical support for one linguistic principle). The substantial empirical evidence for the linguistic principles (in Feynman terms, real guesses) of UG has been questioned (e.g. Evans 2014; but also see Allot and Rey 2017). However, the very formulation of linguistic principles is based on extensive empirical evidence. In formulating these principles, linguists gather judgments from informants who speak a variety of languages, including languages that are only distantly related. Among the facts that candidate principles should explain are (a) why informants judge some sequences of words to be acceptable, but not others, and (b) why informants judge certain word strings to have particular meanings, but not other meanings. Optimally, principles also unify linguistic phenomena that, pretheoretically, appear to be unrelated. This is why Chomsky (1965, p. 6) refers to the phenomena governed by principles of UG as "deep-seated regularities."

In contrast to the array of facts that linguists have at their disposal, child language learners are only exposed to strings of words that are produced by speakers of the local language, and most word strings are produced in contexts that correspond to just one meaning. The characteristic effects of Zipf's law further limit the input experienced by child language learners, restricting the dataset to a small sample of the possible word combinations generated by adult grammars (Yang 2013). Child language learners do not have access to facts about foreign languages, or to facts about which strings of words are not acceptable in a language, or to facts about which meanings cannot be assigned to words strings that are acceptable. As compared to linguists, then, the evidential basis children have for positing linguistic principles is highly circumscribed. As Chomsky (1988, p. 91) summarizes the situation, the formulation of linguistic principles requires "a broad range of evidence that is not available to the child, including evidence from a variety of languages, and evidence acquired by sustained empirical inquiry informed by complex theory construction."

In view of the impoverished linguistic data available to child language learners, the facts we discuss in this chapter render certain kinds of mechanisms implausible as causal forces of language, as envisioned by Fodor (1975). It is highly implausible, for example, that child language learners use construction-specific learning mechanisms, as proposed by advocates of the usage-based approach to language acquisition. The shallow outputs generated by construction-specific learning mechanisms are unable to represent the causal forces of language. It is also highly implausible that child language learners are limited to general-purpose mechanisms, such as distributional analysis and analogy, to cull information and form generalizations based on statistical regularities that are observable in the input. Once we describe the kinds of facts that young children master, it should become clear how improbable it is that children acquire language without substantial assistance from innately specified linguistic knowledge.

Our discussion of the causal forces of language and the poverty of the stimulus will focus on just a fragment of human language. We discuss four kinds of expressions.

In English, these expressions are the words *some*, *any*, and *or*, and question words such as *who* and *what*. Although these expressions appear to be unrelated, we will show that they are all cut from the same cloth – they are governed by the same linguistic principles, which determine both their distributional properties and their meanings.

29.2 The Amalgamation of Linguistic Phenomena

Ideally, the causal forces of language amalgamate disparate-looking linguistic phenomena. The amalgamation of linguistic phenomena poses a challenge to "empiricist language learners," to borrow terminology from Laurence and Margolis (2002, pp. 221–222). Empiricist language learners can be contrasted with nativist language learners. Empiricist learners lack assistance from the principles of Universal Grammar. Instead, empiricist learners employ learning mechanisms that are construction-specific (e.g. Ambridge and Lieven 2011; Lieven and Tomasello 2008; Tomasello 2003). These mechanisms operate on shallow inputs, i.e. strings of words without hierarchical structure (see e.g. Croft 2001; Goldberg 2003, 2006; Pullum and Scholtz 2002). It follows that empiricist learners are not equipped to formulate the kinds of abstract linguistic principles that are postulated by linguists in order to tie different constructions together. This section demonstrates the need for linguistic principles that amalgamate linguistic phenomena that appear unrelated unless, as Chomsky (1988) puts it, they are "informed by complex theory construction."

We begin by laying out some facts about the distribution of the English existential expression *any*. Then we describe facts about the interpretation of the English word for disjunction, *or*. Although the distribution of *any* and the interpretation of *or* appear unrelated at first look, it turns out that both phenomena are governed by the same linguistic principles.

29.2.1 any

The word *any* is referred to as a "negative polarity item." Other negative polarity items include *ever*, *at all*, and *a red cent*. We will be comparing *any* to other kinds of existential expressions, including the positive polarity item *some*. We will refer to lexical items of both kinds as existential expressions, or as "polarity sensitive" expressions.

There are sequences of words in which the word *any* is acceptable, and sequences of words in which *any* is not acceptable. The word *any* is tolerated in the sequences of words in (1a,b).

(1) a) Robin did <u>not</u> drive to <u>any</u> gruesome murder scene.
b) Robin would <u>never</u> drive to <u>any</u> gruesome murder scene.

By contrast, *any* is not tolerated in (2). The asterisk, *, indicates that a string of words is not acceptable. As shown in (3), if *any* is replaced by *some*, the string of words becomes acceptable.

(2) Robin drove to *<u>any</u> gruesome murder scene.
(3) Robin drove to <u>some</u> gruesome murder scene.

Linear order does not explain where *any* can appear in negative sentences. To see this, note that the negative expression *not* precedes the word *any* in (4) but *any* is not tolerated. By contrast, *some* is acceptable in (5), as it was in (3).

(4) As soon as Batman was not looking, Robin drove to *any gruesome murder scene.
(5) As soon as Batman was not looking, Robin drove to some gruesome murder scene.

Another fact about *any* is illustrated in (6), where Speaker A poses a question that contains the negative adverb *never*. Speaker B provides an acceptable answer to A's question, using the word *any*. Speaker B's fragment answer is just as acceptable as a "complete" answer, *Robin would never drive to any gruesome murder scene* (example 1b).

(6) Speaker A: Where would Robin never drive?
Speaker B: To any gruesome murder scene.

Next we will show parallels between the word strings in which *any* is acceptable and the word strings that license a particular interpretation of the disjunction word, *or*.

29.2.2 How any *and* or *Are Related*

Some sequences of words license one interpretation of English *or*, and others license a different interpretation. In some word sequences, *or* can be paraphrased as "one or the other." This interpretation is illustrated in example (7), which speakers judge to be true if just Robin, or just Catwoman, drove the Batmobile to the murder scene. There is no negative expression in (7), just as there is no negative expression in example (8) (previous example 2), where *any* is not tolerated.[1]

(7) Robin or Catwoman drove to the gruesome murder scene. (I don't recall who drove.)
(8) Robin drove to *any gruesome murder scene.

English *or* has a different interpretation in other strings of words. The alternative interpretation arises, for example, in word strings that contain the negative expressions *not* and *never*, as in the examples in (9). We call this alternative meaning the "neither" interpretation. Speakers judge (9a) to be true only if Batman did not see either Robin or Catwoman drive to the murder scene. Comparing the examples in (9) and (10) (previous example 2) indicates that the "neither" interpretation of disjunction is assigned to strings of words that license *any*.

(9) a) Batman did not see Robin or Catwoman drive to the gruesome murder scene.
b) Batman never saw Robin or Catwoman drive to the gruesome murder scene.

(10) a) Robin did not drive to any gruesome murder scene.
b) Robin never drove to any gruesome murder scene.

We saw earlier that linear order does not determine when *any* is acceptable or is not acceptable. That is, the fact that negation precedes *any* does not guarantee its acceptability. This is illustrated in example (11) (previous example 4).

(11) As soon as Batman was not looking, Robin drove to *any gruesome murder scene.

Structural factors are also involved in the interpretation of sequences of words with disjunction. In example (12), the negation marker *not* precedes the disjunction phrase *Robin or Catwoman*, but this phrase is not assigned the "neither" interpretation.

(12) As soon Batman was not looking, Robin or Catwoman drove to the gruesome murder scene. (I don't recall who drove.)

Nevertheless, the English disjunction word *or* licenses a "neither" interpretation in discourse sequences in which *any* is acceptable. This is illustrated in (13). The fragment answer by Speaker B has the same "neither" interpretation as the complete answer, *Batman would never let Robin or Catwoman drive to a gruesome murder scene*. Example (14) illustrates that *any* is acceptable in similar discourse sequences (previous example 6).

(13) Speaker A: What would Batman never do?
Speaker B: Let Robin or Catwoman drive to a gruesome murder scene.
(14) Speaker A: Where would Robin never drive?
Speaker B: To any gruesome murder scene.

Here is the descriptive generalization. English word strings that tolerate *any* license a "neither" interpretation of the disjunction word *or,* and word strings that do not tolerate *any* license a "one or the other" interpretation.

29.2.3 Licensing and Scope

Two factors determine the distribution of the negative polarity item *any* and the "neither" interpretation of *or*. First, the word *any* is accepted in a sequence of words only if it is licensed by a member of a class of linguistic expressions. As we have seen, this class of expressions includes words with a negative cast such as negatives *not* and *never*, but it also includes more affirmative expressions such as the prepositions like *before*, comparative adjectives like *taller* and *stronger*, and the antecedent of conditional (*if* … , *then* …) statements. The class of expressions that license *any* is called downward entailing expressions (see Chierchia 2013; Ladusaw 1979; Linebarger 1980). Downward entailment is a semantic relationship between pairs of sentences. Downward entailing lexical items validate inferences from sentences with general terms to sentences with more specific terms: *Robin arrived without a car* entails *Robin arrived without the Batmobile*.

Downward entailing expressions license negative polarity items like *any*. Downward entailing expressions also license the conjunctive (e.g. "neither") interpretation of disjunction words. A second factor governs the acceptability of *any* and the interpretation of *or*. This is an abstract structural notion referred to as c-command (e.g. Lasnik 1976; Reinhart 1981; Radford 2004). For a downward entailing expression to license *any,* it must c-command the position in which *any* resides (see Crain and Thornton, this volume, for a definition of c-command).

All accounts of language acquisition are obliged to explain how child language learners establish these two factors that govern the acceptability of *any* and the interpretation of *or*. As we have seen, linguists are able to establish candidates for relevant linguistic principles, in part, by comparing pairs of word strings. One should ask how plausible it

is to suppose that child language learners have the cognitive resources to record, remember, and make the requisite comparisons between pairs of word strings. In formulating the notions of c-command and downward entailment, moreover, linguists are able to draw on evidence about the unacceptability of certain word strings, and the impossibility of assigning certain meanings to acceptable strings of words. Child language learners lack information about nonexpressions and information about impossible interpretations.

It is conceivable that child language learners exploit other sources of information. But, in the absence of specific details about these sources of information, a learning-theoretic approach to language acquisition is hard pressed to explain how child language learners discover causal notions like downward entailment and scope (c-command), or equivalent notions. It is noteworthy, in our view, that to date the learning-theoretic approach has failed to engage with the deep-seated regularities established by linguistic research.

29.3 Questions and Statements

The linguistic phenomena we reviewed so far are just the tip of a large iceberg. We turn our attention next to the linguistic behavior of information-seeking questions. In English, these are questions that typically begin with *wh*-words, such as *who* and *what*. There are declarative statements that correspond to information-seeking questions; these statements contain the existential expressions *someone* and *something*. Like *any* and *or*, linguists have proposed principles that amalgamate information-seeking questions and their statement counterparts.

In the early days of generative grammar, Chomsky (1964) introduced a transformational rule that derived information-seeking questions with *wh*-words *who* and *what* from structures that were used to derive declarative sentences with the expressions *someone* and *something*. According to the analysis Chomsky proposed, the indefinite expression *some* (*one*, *thing*) was the source of information-seeking questions with *who* and *what*. The transformational rule was devised to explain the pair-wise symmetries that can be found in English between declaratives and *wh*-questions, as well as pair-wise anomalies. An acceptable pairing of a *what*-question and the corresponding declarative statement with *something* is witnessed in (15). An unacceptable pair with *who* and *someone* is illustrated in (16).

(15) a) He has something of yours
b) What does he have of yours?
(16) a) He found *someone of yours.
b) *Who did he find of yours?

Example (17) is an acceptable pair consisting a *whose*-question and a declarative statement with the possessive existential expression *someone's*. Example (18) illustrates an unacceptable pair consisting of an information-seeking question with the possessive *wh*-word *what's* and the corresponding declarative statement with the possessive existential expression *something's*.

(17) a) Someone's cover is on the floor.
b) Whose cover is on the floor?

(18) a) *Something's cover is on the floor.
b) *What's cover is on the floor?

These pairings of acceptable and unacceptable strings of words bear witness to a semantic relationship between existential statements and *wh*-questions in English. However, it seems unlikely that the child language learner will detect this relationship based on experience. Although child language learners have access to the acceptable word sequences, such as (15) and (17), they do not have access to information about strings of words that are anomalous, such as (16) and (18). In order to formulate principles that determine the correspondences between information-seeking questions and existential statements, young children acquiring English have a much more slender evidential base than linguists do. We turn next to the important role played by cross-linguistic facts as a source of information about the deep forces that shape language. Again, this information is available to linguists, but not to the vast majority of child language learners.

29.4 Cross-Linguistic Evidence

In English, the relationship between the *wh*-words *who* and *what* and the existential expressions *someone* and *something* only becomes evident when pairs of word strings are considered (including unacceptable pairs, which are not in the input to child language learners). In contrast to English, many other languages wear the correspondence between *wh*-words and existential expressions on their sleeves. Mandarin Chinese is one example. The Mandarin word *shenme* "what" functions both as an interrogative marker in information-seeking questions, and as an existential expression in declarative sentences. The ambiguity of Mandarin *shenme* "what" is illustrated by the sequence of words in (19). Not surprisingly, a similar ambiguity is manifested by Mandarin *shei* "who." (Example 19 is from Aoun and Li 1993, p. 212.)

(19) Mandarin
Ta yiwei wo xihuan shenme
he think I like what
a) "What does he think I like?"
b) "He thinks that I like something."

With a simple change in prosody (the intonation contour of a string of words), Mandarin *wh*-words like *shenme* "what" and *shei* "who" can be used either to make a statement or to pose an information-seeking question.

In other languages, *wh*-words and disjunction are the basic building blocks for forming existential expressions. The examples in (20) show that the Japanese existential expression corresponding to English *someone* is formed by combining the *wh*-word *dare* "who" and the disjunction word *ka* "or," and the Japanese existential expression corresponding to English *something* is formed by combining the *wh*-word *nani* "what" and the disjunction word *ka* "or." Example (20c) illustrates the use of the disjunction word *ka* "or" in a declarative statement.

(20) Japanese
a) dare "who" nani "what"
b) dare-**ka** "someone" nani-**ka** "something'
c) Taroo-**ka** Hanako-ga kita.
"Taroo or Hanako came."

Similar combinations are found in Russian and in Sinhala, as illustrated in (21) and (22), and in many other languages (examples 20–22 are adapted from Jayaseelan 2001).

(21) Russian
a) kto "who" čto "what"
b) kto-**to** "someone" čto-**to** "something"
c) kto-**to** ne **to** shel, ne **to** exal
"Someone was either walking or riding (it's not clear which)."

(22) Sinhala
a) kauru "who" mokaka "what"
b) kau-**də** "someone" mokak **də** "something"
c) mahatteatə tee **də** koopi **də** oonə?
"Do you (the gentleman) want tea or coffee?"

In other languages, the existential expressions corresponding to English *anyone* and *anything* are formed by combining *wh*-words and disjunction words. In Malagasy, for example, the expression corresponding to English *anything* is literally rendered as *or what or what*, and the expression corresponding to English *anyone* is *or who or who* (example 23 is from Paul 2005).

(23) Malagasy
Tsy matahotra na inona na inona izy.
NEG fear or what or what 3(NOM)
"He doesn't fear anything."

In some languages, *wh*-words alone (without disjunction) are interchangeable with existential expressions (corresponding to English *any*). For example, in Mandarin Chinese, both the question word *shenme* "what" and the existential expression *renhe* "any" are licensed by the negative quantifier *meiyouren* "nobody," without altering the meaning of the sentence. This is illustrated in examples (24) and (26). By contrast, the Mandarin universal quantifier *meigeren* "everybody" is not downward entailing (in the predicate phrase). If the universal quantifier *meigeren* "everybody" replaces *meiyouren* "nobody," then sentences with *shenme* "what" become information-seeking questions, as shown in (25). When the universal quantifier *meigeren* "everybody" replaces *meiyouren* "nobody," then sentences with *renhe* "any" are unacceptable, as shown in (27) (examples 24–27 are from Crain and Zhou 2018).

(24) **Meiyouren** chi **shenme** shuiguo.
nobody eat what fruit
"Nobody ate any fruit."

(25) **Meigeren** chi **shenme** shuiguo.
everybody eat what fruit
"What fruit did everybody eat?"

(26) **Meiyouren** chi **renhe** shuiguo.
nobody eat any fruit
"Nobody ate any fruit."

(27) **Meigeren** chi ***renhe** shuiguo
everybody eat any fruit
"Everybody ate any fruit."

These cross-linguistic facts directly disclose semantic relationships between a class of expressions: *wh*-words, existential expressions, and disjunction. In English, the class of expressions is expressed using individual lexical items: *wh*-words like *who* and *what*, the polarity sensitive expressions *something, someone, anything,* and *anyone*, and the disjunction word *or*. In other languages, certain members of this class of lexical items are combined to form other members of the class, or certain expressions are used interchangeably. Cross-linguistic evidence of this kind is available to linguists, but it is not available to monolingual children acquiring English or any other language.

29.5 The Ubiquity of Evidence

Another way that the primary linguistic data may be impoverished is that the data may not be sufficiently ubiquitous to account for the knowledge manifested by *all* normal children (cf. Chomsky 1975, p. 31; Sampson 1989, 1999). As Pullum and Scholtz (2002, pp. 14–15) state the issue:

> … there could be positive evidence for the correctness of some rule or principle, evidence that could be found in language use by an adult linguist doing a really intensive search, but would not emerge in conversational data anywhere near often enough to guarantee that any particular child would ever encounter it. This, we think, is the basis for the argument that most clearly deserves to be referred to as the argument from the poverty of the stimulus.

At issue is not whether relevant evidence exists; the issue concerns the robustness of evidence. As Lasnik and Crain (1985) note, if the relevant evidence is not robust, then at least some children won't come by it, and these children will not converge on the grammar of the linguistic community. But this does not happen. All (normal) children converge on a grammar that is equivalent to that of adults. Therefore, the relevant evidence must be available in abundance for child language learners who take wrong turns in the course of language acquisition. Alternatively, child language learners converge on a grammar that is equivalent to that of adults without taking many wrong turns along the way.

In some cases, it is highly implausible to suppose that the relevant evidence exists at all, much less available in abundance. To see this, we return to the differences in the distributional and interpretative properties of sentences with *some* and *any*. The differences in interpretation can be observed in negative sentences, where both expressions are acceptable. For example, both *some* and *any* are permitted in (28) and (29). In (28), *some* is interpreted as taking scope over negation. In (29), negation takes scope over *any*. The glosses below the examples indicate their different interpretations.

(28) Tony did ***not*** eat ***some*** of the cookies in the pantry.
Meaning: There are some cookies that Tony did not eat.

(29) Tony did ***not*** eat ***any*** of the cookies in the pantry.
Meaning: There are no cookies that Tony ate.

Recall the distributional differences between *some* and *any*; *some* can appear in positive statements, where *any* is not tolerated. The difference in acceptability is illustrated in (30) and (31).

(30) There are some cookies in the pantry.
(31) There are *any cookies in the pantry.

Despite the differences between *some* and *any* in simple sentences like (30) and (31), the syntactic and semantic equivalence of *some* and *any* becomes readily apparent in more complex sentences. When simple sentences like (30) and (31) are embedded inside more complex linguistic structures, both the distributional and the interpretive differences between English *some* and *any* disappear.

One linguistic context in which the differences between *some* and *any* are cancelled is in sentences with "external" negation. Negation is "external" when it is positioned outside the clause that contains the expression *some* or *any*. An example is (32). This sentence has been constructed by embedding the previous unacceptable sentence with *any* (31), *there are any cookies in the pantry*, within the scope of external negation, *Julia did not say that* . . . . When the (unacceptable) string of words with *any* is positioned inside the scope external negation, as in (32), it becomes completely acceptable. Not only this, but *some* and *any* are equivalent in meaning when they appear in the scope of an external negation. This can be seen by noting that sentences (32) and (33) are true in the same circumstances

(32) Julia did ***not*** say that there are ***any*** cookies in the pantry.
(33) Julia did ***not*** say that there are ***some*** cookies in the pantry.

Another linguistic context cancels the usual differences between *some* and *any*. The differences are canceled when these expressions are in the antecedent clause of a conditional (*If* . . . , *then* . . .) statement. As with external negation, unacceptable strings of words with *any,* such as (31), are acceptable when they are introduced into this linguistic structure. And, as with external negation, the difference in meaning between *some* and *any* (in 28 and 29) vanishes when these expressions are in the antecedent clause of a conditional. This is shown in sentences (34) and (35), which are both true in exactly the same circumstances.

(34) ***If*** there are ***any*** cookies in the pantry, Tony will find them.
(35) ***If*** there are ***some*** cookies in the pantry, Tony will find them.

These examples demonstrate an equivalence between English *some* and *any*. So, evidence of the equivalence between *some* and *any* does exist in English, as in other languages. The question is whether the relevant evidence is available to children acquiring English. The evidence consists of pairs of complex sentences. In order to detect the relevant equivalences, then, child language learners would have to be able to recall and mentally compare pairs of complex sentences. It is highly doubtful that children have the resources to exploit these data in the course of language acquisition.

29.6 When Children Ignore the Primary Linguistic Data

There is another way in which children's linguistic hypotheses are underdetermined by the primary linguistic data. Instead of attempting to match the linguistic input they encounter, child language learners sometimes adopt hypotheses that are attested in

other languages, but not in the local language. Metaphorically, child language learners can be said to speak a fragment of a foreign language, rather than the language of the linguistic community in which they are raised. One example of this is the acquisition of the meaning of disjunction words in negative sentences. In interpreting negative sentences with disjunction, languages can be divided into two classes.

In one class of languages negation takes scope over disjunction. Negative sentences with disjunction are assigned the "neither" interpretation in these languages. In English, if negation takes scope over disjunction in the surface syntax, the negation also takes scope in the semantic interpretation.

English is in this class of languages. This is illustrated in (36), which generates two entailments: *The pig didn't eat the pepper* and *The pig didn't eat the carrot*.

(36) The pig did ***not*** eat the pepper ***or*** the carrot.

In another class of languages, disjunction takes scope over negation at the level of semantic interpretation, regardless of the surface position of disjunction. Mandarin is a language in which disjunction takes scope over negation. Example (37) is the Mandarin Chinese analogue to the English example (36), where the Mandarin disjunction word is *huozhe* "or" and one Mandarin word for negation is *meiyou*. Negation precedes the word for disjunction, *huozhe*, just as in the English example (36). Nevertheless, adult speakers of Mandarin judge (37) to express a different meaning. The meaning for Mandarin-speaking adults can be paraphrased using a English cleft sentence, where disjunction takes scope over negation in the surface syntax: *It's the pepper or the carrot that the pig didn't eat*.

(37) Mandarin
Zhu ***mei*** chi qingjiao ***huozhe*** huluobo.
pig not eat pepper or carrot
"It's the pepper or the carrot that the pig didn't eat."

Inspired by a conjecture advanced in Szabolcsi (2002), Goro (2004) proposed that disjunction words across languages are governed by a lexical parameter, called the *disjunction parameter* (cf. Szabolcsi 2002; Goro 2004; Crain, Goro and Minai 2007; Crain, Goro and Thornton 2006; Zhou and Crain 2009). The disjunction parameter has two values, corresponding to the different scope assignments that different languages generate for negative sentences with disjunction: (NEG > OR) versus (OR > NEG). For adult Mandarin-speakers, the disjunction word *huozhe* is interpreted as taking scope over local negation, as illustrated in (37). This is the positive value of the disjunction parameter [+P]. By contrast, disjunction words have the negative value [–P] in languages like English, as illustrated by example (36). In this class of languages, disjunction words are interpreted in their surface position (*in situ*) in negative sentences.

The different values of the disjunction parameter stand in a subset/superset relation. On the [–P] value of the parameter, negative sentences with disjunction are true in just one circumstance, where both disjuncts are excluded: NOT A and NOT B. By contrast, the [+P] value of the parameter makes negative sentence with disjunction true in a broader range of circumstances. In [+P] languages, negative sentences with disjunction are true in circumstances in which both disjuncts are excluded, but these sentences are

also true in circumstances where only one of the disjuncts is excluded: either NOT A, or NOT B.

Based on the asymmetry in the truth conditions of negative sentences with disjunction, Goro (2004) reasoned that children would confront a potential learnability problem if they initially selected the (superset) value of the disjunction parameter, [+P]. Having selected this value of the parameter, children acquiring English, a [–P] language, would overgenerate. That is, if children acquiring a [–P] language initially adopted the [+P] setting of the disjunction parameter, they would accept negative sentences with disjunction in circumstances in which adult English speakers reject them. In the absence of negative evidence, then, it is difficult to see how children who initially adopt the [+P] value of the disjunction parameter could narrow in on just the one circumstance that makes negated disjunctions true for adult speakers of a [–P] language.

Based on these considerations of language learnability (in the absence of negative evidence), Goro (2004) predicted that children acquiring all languages initially select the more restrictive, subset value of the disjunction parameter, [–P]. As an empirical consequence, child language learners acquiring [+P] languages, such as Mandarin, are predicted to initially interpret negated disjunctions in the same way as English speakers do, with negation taking scope over disjunction (NOT > OR). The empirical predictions associated with the disjunction parameter have been examined in more than 10 languages to date. The prediction that all children should initially adopt the [–P] value of the disjunction parameter has been confirmed, at least so far (e.g. Crain 2012; Geçkin, Thornton, and Crain 2017; Goro and Akiba 2004a, 2004b; Pagliarini, Crain, and Guasti 2018; Verbuk 2007; Zhou and Crain 2009).

29.7 Conclusion

In postulating principles that govern human language, linguistic research draws on a range of data that are not available to child language learners. To illustrate the discrepancy between the data used by linguists in theory construction and the data available to children, we took a look at some of the principles that govern a class of lexical items. In English, these lexical items included *wh*-words like *what* and *who*, existential expressions like *someone* and *anyone*, and the word for disjunction, *or*. In contrast to English, other languages compose some of the corresponding lexical items out of others. For example, the Japanese word corresponding to English *someone* is composed of the *wh*-word *dare* "who" and the word for disjunction *ka* "or." In additional to cross-linguistic facts, linguistic research compares acceptable and unacceptable pairs of words strings, including complex word strings. The breadth of (disparate-looking) phenomena that linguists use to discover the principles of language, as compared to the primary linguistic data available to child language learners, underscores the implausibility of supposing that children figure out the causal forces of language based on experience. The alternative is to suppose that the principles of language are innately specified in Universal Grammar.

Endnote

1 The use of disjunction in (7) may seem odd. Disjunction indicates that the speaker is uncertain about the events that took place. If the speaker knows which person, Robin or Catwoman,

drove to the gruesome murder scene, then it is more felicitous to just mention the person who drove, avoiding a disjunctive statement.

References

Ambridge, Ben, and Elena V. Lieven. 2011. *Child Language Acquisition: Contrasting Theoretical Approaches*. Cambridge: Cambridge University Press.

Allott, Nicholas, and Georges Rey. 2017. The many errors of Vyvyan Evans' The Language Myth. In *The Linguistic Review* 34: 1–20.

Aoun, Joseph, and Yen-hui Audrey Li. 1993. *Syntax of Scope*. Cambridge: MIT Press.

Chierchia, Gennaro. 2013. *Logic in Grammar: Polarity, Free Choice and Intervention*. Oxford: Oxford University Press.

Chomsky, Noam. 1964. *Current Issues in Linguistic Theory*. The Hague: Mouton.

Chomsky, Noam. 1965. *Aspects of the Theory of Syntax*. Cambridge: MIT Press.

Chomsky, Noam. 1975. *Reflections on Language*. New York: Pantheon Books.

Chomsky, Noam. 1981. *Lectures on Government and Binding*. Dordrecht: Foris Publications.

Chomsky, Noam. 1988. *Language and Problems of Knowledge*. Cambridge: MIT Press.

Croft, William. 2001. *Radical Construction Grammar: Syntactic Theory in Typological Perspective*. Oxford: Oxford University Press.

Crain, Stephen. 2012. *The Emergence of Meaning*. Cambridge: Cambridge University Press.

Crain, Stephen, Goro Takuya, and Rosalind Thornton. 2006. Language acquisition is language change. *Journal of Psycholinguistic Research* 35: 31–59.

Crain, Stephen, Goro Takuya, and Utako Minai. 2007. Hidden units in child language. In *Mental States: Nature, Function and Evolution,* edited by Andrea Schalley, and Drew Khlentzos, 275–294. Amsterdam: John Benjamins.

Crain, Stephen, and Peng Zhou. 2018. The meaning of question words in statements in child Mandarin. In *Semantics in Language Acquisition. Trends in Language Acquisition Research 24,* edited by Kristen Syrett and Sudha Arunachalam, 250–274. Amsterdam: John Benjamins. https://doi.org/10.1075/tilar.24

Evans, Vyvyan. 2014. *The Language Myth*. Cambridge: Cambridge University Press.

Feynman, Richard. 1965. *The Character of Physical Law*. Cambridge: MIT Press.

Fodor, Jerry A. 1975. *The Language of Thought*. New York: Thomas Y. Crowell.

Geçkin, Vasfiye, Rosalind Thornton, and Stephen Crain. 2017. Children's Interpretation of Disjunction in Negative Sentences: A Comparison of Turkish and German. *Language Acquisition,* 25: 197–212. https://doi.org/10.1080/10489223.2017.1280796

Goldberg, Adele. 2003. Constructions: A New Theoretical Approach to Language. *Trends in Cognitive Sciences,* 7: 219–224.

Goldberg, Adele. 2006. *Constructions at Work: The Nature of Generalization in Language*. Oxford: Oxford University Press.

Goro, Takuya. 2004. *The Emergence of Universal Grammar in the Emergence of Language: The Acquisition of Japanese Logical Connectives and Positive Polarity*. PhD dissertation, University of Maryland.

Goro, Takuya, and Sachie Akiba. 2004a. The acquisition of disjunction and positive polarity in Japanese. In *Proceedings of the 23rd West Coast Conference on Formal Linguistics*, edited by Vineeta Chand, Ann Kelleher, Angelo J. Rodríguez, and Benjamin Schmeiser, 251–264. Somerville, MA: Cascadilla Press.

Goro, Takuya, and Sachie Akiba. 2004b. Japanese disjunction and the acquisition of positive polarity. In *Proceedings of the 5th Tokyo Conference on Psycholinguistics*, edited by Yukio Otsu, 137–162. Tokyo: Hituzi Syobo Publishing Company.

Jayaseelan, K. A. (Karattuparambil Achuthan). 2001. *Questions and question-word incorporating quantifiers in Malayalam. Syntax* 4: 63–93.

Ladusaw, William. 1979. *Polarity sensitivity as inherent scope relations*. PhD dissertation, University of Texas, Austin.

Lasnik, Howard. 1976. Remarks on coreference. *Linguistic Analysis* 2: 1–22.

Lasnik, Howard, and Stephen Crain. 1985. On the acquisition of pronominal reference: Review of: L. Solan, Child language and the theory of grammar. *Lingua* 65: 135–154.

Laurence, Stephen, and Eric Margolis. 2002. Radical concept nativism. *Cognition* 86: 25–55.

Linebarger, Marcia. 1980. *The grammar of negative polarity*. PhD dissertation, MIT.

Lieven, Elena V. M., and Michael Tomasello. 2008. Children's first language acquisition from a usage-based perspective. In *Handbook of Cognitive Linguistics and Second Language Acquisition,* edited by Peter Robinson and Nick C. Ellis, 168–196. New York: Routledge.

Pagliarini, Elena, Stephen Crain, and Maria Teresa Guasti. 2018. The compositionality of logical connectives in child Italian. *Journal of Psycholinguistic Research* 47 (6): 1243–1277. https://doi.org/10.1007/s10936-018-9596-1

Paul, Ileana. 2005. Disjunction in free choice and polarity in Malagasy. In *Proceedings of the 2005 Annual Conference of the Canadian Linguistic Association, edited by Claire Gurski*. http://cla-acl.ca/wp-content/uploads/actes-2005/Paul.pdf

Pullum, Geoffrey, and Barbara Scholtz. 2002. Empirical assessment of stimulus poverty arguments. *The Linguistic Review* 19: 9–50.

Radford, Andrew. 2004. *English Syntax: An Introduction*. Cambridge, UK: Cambridge University Press.

Reinhart, Tanya. 1981. Definite NP Anaphora and C-command Domains. *Linguistic Inquiry* 12: 605–635.

Sampson, Geoffrey. 1989. Language acquisition: Growth or learning? *Philosophical Papers* 18: 203–240.

Sampson, Geoffrey. 1999. *Educating Eve*. London: Cassell.

Szabolcsi, Anna. 2002. Hungarian disjunctions and positive polarity. In *Approaches to Hungarian 8*, edited by Istvan Kenesei and Peter Siptar, 217–241. Budapest: Akademiai Kiado.

Tomasello, Michael. 2003. *Constructing a Language: A Usage-Based Theory of Language Acquisition*. Cambridge, MA: Harvard University Press.

Verbuk, Anna. 2006. The acquisition of the Russian or. In Proceedings of the 34th Western Conference on Linguistics, edited by Erin Brainbridge and Brian Agbayani, 443–455. Fresno, CA: Department of Linguistics, California State University.

Yang, Charles (2013) Ontogeny and phylogeny of language. *Proceedings of the National Academy of Science, USA* 110 (16): 6324–6327.

Zhou, Peng, and Stephen Crain. 2009. Scope Assignment in Child Language: Evidence from the Acquisition of Chinese. *Lingua,* 119: 973–988. doi:10.1016/j.lingua.2009.01.001

30

Chomsky on the Evolution of the Language Faculty: Presentation and Perspectives for Further Research

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30.1 Introduction

What might be the most remarkable thing about Chomsky's view of the evolution of language is that it has changed very little throughout the years (see Chomsky 2016). Since the 1960s, he has claimed the following:

- Language is species-specific (no species other than mankind has anything even remotely comparable to language).
- Language is a biological endowment.
- Language is not the product of evolution in the sense that it is not an adaptation (see below for a more detailed discussion).
- Language is not first and foremost a tool for communication.
- Language emerged as a whole, rather than gradually (a so-called saltationist position).

Surprisingly, these positions have occasionally been interpreted as an attack against a biological approach to language on the rather flimsy grounds that all biological approaches should see language as an adaptation. Given the emphasis that Chomsky has always put on a biological conception of language (against most nongenerative linguists until recently), this seems a gratuitous view.

What is most remarkable about this continuity in Chomsky's thought about language is that it takes place against a theoretical landscape in constant flux, the landscape of generative grammar (GG). While this is not the place to give a history of GG, there is one major change that has affected the very notion of a Faculty of Language and hence the stance in the GG community regarding the question of the evolution of the Language Faculty. This will be our point of departure.

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30.2 The Faculty of Language: Then and Now

A central question in any evolutionary query is the very object of the query: what has evolved? While a lot of approaches to the evolution of language (for a recent example, see Christiansen and Chater 2016) center on E-languages (the various and fuzzily delimitated languages that are used for communication in human groups, e.g. French, English, Tagalog, etc.), this is not the case in the Chomskyan paradigm. Chomsky (1986) introduced a central distinction between E-languages and I-language[1], the internalized knowledge of language that each speaker has and which is the result of the interaction between his or her language faculty and the (limited) experience that he or she had of his or her mother tongue during language acquisition. The object of linguistics is, in that perspective, not E-languages, but I-language. And the object of any question about language evolution is the Faculty of Language, the ability, unique to the human species, that allows all humans to develop an I-language, regardless of the linguistic environment in which they are born or raised. In other words, if anything evolved in the biological sense, it was not E-languages (as any human infant can acquire any E-language whatsoever given the relevant linguistic environment), but rather, the ability to develop an I-language, i.e. the Faculty of Language. Thus, in terms of the question of language evolution, a lot will depend on what exactly is meant by the Faculty of Language, notably whether there is any chance of answering the question of its evolution, and whether to see language as an adaptation in the strong sense that it evolved to fulfill a specific, adaptive, function. And it is here that the GG paradigm has undergone a major change.

A good outline of this shift and of its consequence for the question of evolution is given in Chomsky (2010). While the notion of *biolinguistics* was introduced by Massimo Piattelli-Palmarini at an international conference in 1974, following Lenneberg (1967), the view of the language faculty at the time saw it as "rich, highly structured, and substantially unique to this cognitive system" (Chomsky 2010, p. 46). As pointed out by Pinker and Bloom (1990), under such a view, it makes sense to consider that the Faculty of Language is an adaptation, progressively evolved through natural selection to fulfill some specific function. This is however in tension with Chomsky's views, according to which the Faculty of Language evolved as a whole (in one step, i.e. in a saltationist way). However, the introduction of the Principles and Parameters approach (see Chomsky 1986) has changed the situation in major ways. Principles are invariant and operate beyond language as they have to do with computational efficiency. Parameters can be set to different values. While principles explain the universality of grammar, parameters account for the variability of E-languages. The question relative to language evolution then becomes that of whether there is anything specific to the Language Faculty and if so, what. This corresponds to the distinction between the *Faculty of Language broadly understood* and the *Faculty of Language narrowly understood* introduced in Hauser, Chomsky, and Fitch (2002/2010).[2]

The Faculty of Language narrowly understood (FLN) corresponds to "the abstract linguistic computational system alone, independent of the other systems with which it interacts" (Hauser, Chomsky, and Fitch 2010, p. 17). As such, it is subject to the principles that characterize Universal Grammar (UG) and is a subset of the Faculty of Language broadly understood (FLB). The FLB gathers the FLN and the systems with which it interacts, i.e. the conceptual-intentional system and the sensory-motor system. Very roughly, the first provides the "meaning," while the second has to do

with externalization and notably with externalization for communication. What is most relevant here is the FLN and its characterization. The FLN has the property of producing discrete infinity (an infinity of discrete sentences) from a finite set of elements and the computational operation that makes this possible is *recursion* (more technically, *Merge*). Hauser, Chomsky, and Fitch (2010) have insisted on the idea that it is this computational operation that is relevant to the question of language evolution. They argued that "although many aspects of FLB are shared with other vertebrates, the core recursive aspect of FLN currently appears to lack any analog in animal communication and possibly other domains as well" (Hauser, Chomsky, and Fitch 2010, 19). As the paper is oriented toward comparative psychology, this obviously makes sense. In such a perspective, looking for what is not shared with other species is crucial regarding the evolution of a faculty that, as language, is species-specific. Additionally, the authors advocate investigating recursion not only from the viewpoint of language, but also in other cognitive domains, more widely shared among animal species, such as number, social relationships and navigation, where it might also apply.

So, to sum up, the question of the evolution of language concerns the FLN rather than the FLB, and the FLN is reduced to a single computational operation, recursion. This *Minimalist* position (see Chomsky 1995/2015) has the advantage of reopening the question of language evolution by radically simplifying the FLN. While the initial, complex view of the FLN seemed to make a strongly adaptationist (and progressive rather than saltationist) approach mandatory, this difficulty disappears under Minimalism. Additionally, the question of E-languages is now entirely a question of externalization, that is of the interaction between the FLN and the sensory-motor system, a question of historical, not biological import. Let us now turn to how Chomsky's main positions about the evolution of language articulate themselves with this new view of the FLN.

To recapitulate, Chomsky sees language as species-specific, and as a biological endowment. He claims that language did not evolve as an adaptation for any specific function and that language is not primarily a tool for communication. Finally, he insists on a saltationist account, in which the FLN emerged in a single step, rather than in a progressive and piecemeal way.

In Hauser, Chomsky, and Fitch (2010), the authors advocate investigating recursion (the computational operation that makes the FLN species-specific to humans) not only in the domain of language, but also in other domains, such as counting, social relationships and navigation. This is clearly linked to the idea that recursion itself is not "new," rather what is new in the FLN is its range of application. This leads rather naturally to the notion that the FLN is a species-specific exaptation (a reutilization for other purposes of a feature that initially evolved as an adaptation for another function: see Gould, and Vrba 1982) and not an adaptation. Thus, it is not recursion as such that is species-specific, but rather its use in the specific domain of language. The fact that recursion is the only species-specific part of the FLN also makes a saltationist account mandatory. While recursion, as a computational operation, may be limited in a cognitively modular sense (for instance, to keep track of hierarchical social relationships or to navigate the environment) or be constrained by other cognitive restrictions (linked to performance) such as working memory, it cannot be had "in part." One either has recursion (notwithstanding modular or performative limitations) or not. In other words, its emergence as the FLN cannot be the result of a progressive process but must have occurred in a single step. Thus, the emergence of the Minimalist Program and the new view of the FLN it entails has made all of Chomsky's tenets about language evolution very reasonable.

One question that I want to discuss here, because it opens new avenues for research is the domain of the FLN. Should it really be seen as limited to Merge? The view that it should was qualified in Fitch, Hauser and Chomsky (2005), where the authors recognized that the FLN might contain more than Merge, a point also insisted on by Pinker and Jackendoff (2005). One interesting question, thus, is what else the FLN could encompass. The most obvious extensions to the FLN would seem to be found in the FLB, i.e. in the sensory-motor and conceptual-intentional interface systems. Here I want to follow the trail of Chomsky's strongly reiterated claim throughout the years that language is not primarily a tool for communication, but rather, a tool for thought.

30.3 Language Is Not Primarily a Tool for Communication

As we have just seen, Chomsky has an exaptationist view of language evolution. While this basically means that the FLN (seen as the use of recursion in language) did not evolve as an adaptation for a specific function, it nevertheless does not mean that an exaptation is not in need of an account of some kind. So, is there a reason why one should discount, as Chomsky does, the possibility that the FLN was an exaptation for communication? In other words, why not think that the use of recursion in language, i.e. *Merge*, emerged to facilitate communication?

30.3.1 Language Uniqueness

The major problem with the view that Merge emerged to facilitate communication is language uniqueness. As Bickerton (2009) has pointed out, while communication (in the broad sense of transfer of information) is ubiquitous in the living world, language is unique, inasmuch as it has Merge and allows for discrete infinity. This might seem like a minor objection.

If, as hinted in Hauser, Chomsky, and Fitch (2010), animal species have recursion in noncommunicative modular systems, why not think that if Merge is the only difference between language and animal communication systems, Merge could have been exapted in the FLN to allow more widespread communication in the human species? In other words, contrary to Chomsky's claims, language would be primarily a tool for communication. Language would be basically in continuity with animal communication systems. There are, however, quite a few problems with this proposal.

First of all, while animal communication systems seem limited to around 30 different signals with different contents (see Reboul 2017), language is in principle unlimited in the range of different contents it can communicate. This raises the question of why animal communication systems are so drastically limited relative to language, as well as the related question of why only humans needed a more extensive communication system. One of the most popular answers to this question (see, e.g. Tomasello 2010) is that humans have a uniquely cooperative and altruistic sociality relative to all other animal species, including primates. Apart from any doubt that one might have about such an optimistic view of human sociality (for a detailed discussion, see Reboul 2017), this raises the question of where all this unlimited content that humans can communicate comes from. While one may legitimately think that animal conceptual systems are less limited than the range of their communicative signals suggest, there still are strong indications that human conceptual apparatuses are cognitively a lot

more powerful than anything found in nonhuman species. While social explanations have also been proposed for the emergence of higher cognitive abilities among primates and particularly among humans, it is not clear that these hypotheses fare very well under scrutiny. The Machiavellian view (see Byrne, and Whiten 1988, Whiten, and Byrne 1997) argues that higher intelligence evolved in an evolutionary arms race to deceive and manipulate other group members in social animals. However, the paucity of deception in the animal world (see Searcy and Nowicki 2005), even among apes, sheds doubt on the Machiavellian hypothesis. Tomasello's (2014) view, according to which human thinking emerged due to social pressures from human altruism, does not fare much better. Apart from any doubt one may harbor about human altruism, the main problem is that it is not clear why altruism as such should lead to higher cognitive capacities.

There is another major discontinuity between language and other animal communication systems. Language is displaced or decoupled[3] in a strong sense. Human language is unique not only in its discrete infinity but also because the contents communicated can be independent of the situation of communication: they don't have to relate to what is present in the environment of the communicators. One can in principle talk of entities that are not present in the communication space, but also of abstract entities and even of nonexistent objects, and independently of any actual, future or potential action.[4] In contrast, animal communication seems limited to concrete (perceptible) objects that are present in the environment, when it is "referential" rather than merely devoted to regulating the social interaction. One major question is where decoupling in the strong, human, sense, came from. As we will see below, decoupling in this strong sense is absent not only from all animal communication systems, and even from the communicative acts of the animals engaged in animal language programs. One might want to argue that decoupling evolved through the interface between the FLN (merge) and the sensory-motor system. There is, however, a problem with this thesis.

The interaction between the FLN and the sensory-motor system is directly linked to externalization, and externalization has a communicative function (indeed, one could say that the communicative part of human language is this interface). If this is the case, it would be very unlikely that decoupling could be due to the interface between the FLN and the sensory-motor system. This is because decoupling makes deception easier because the audience, in the absence of what the communication is about, cannot verify its veracity. There is a general consensus that communication should be profitable for both the sender and the receiver, and deception is obviously not in general profitable to the receiver (see Krebs, and Dawkins 1984). Thus, it is very unlikely that decoupling would emerge in a communication system. Hence, the origin of decoupling is unlikely to be found in the interface between the FLN and the sensory-motor system.

This other main difference between language and animal communication systems, in addition to Merge, has been relatively ignored in the literature on the evolution of language. So, let us turn to decoupling and to the Chomskyan idea that language is not primarily a tool for communication, but rather, a tool for thought.

30.3.2 Language as a Tool for Thought

It seems that there is a common factor in the limitations of animal communication systems and of animal conceptual apparatuses. As pointed out above, the question of why Merge emerged in the FLN and not in other animal communication systems

may be the question of where the infinity of different contents that Merge allows to communicate come from in the human species. In other words, and contrary to Hauser, Chomsky, and Fitch (2010), there would be major discontinuities between human and nonhuman thought.

While there is evidence that some primate species can master, after numerous trials, abstract relations such as *similar* and *different*, it seems clear that they are limited in their conceptual range in a way that humans are not. A first indication of this lies in the very different vocabulary sizes of human children and animals engaged in animal language programs (where animals of different species are taught sign or symbolic languages). While insistence is often (and rightly) put on the absence of anything like syntax in these animals, it is also notable that they are limited in the size of their vocabularies, learning around 250/300 "words," about the size of the vocabulary of a three-year-old child, at the most. By contrast a six-year-old has a vocabulary of around 10,000 words (see Anderson 2004 on animal language programs, Bloom 2000 for children's vocabularies, and Reboul 2017 for a more extensive discussion). One might argue that nonhuman animals are more limited than humans in the number of associations they can master (words in animal language programs are typically considered to be associations between forms and meanings), but recent works have demonstrated that this is not the case (see, e.g. Fagot, and Cook 2006; Kaminsky, Call, and Fisher 2004; Pilley, and Reid 2011). Rather the limitation seems to lie in the nature of concepts that animals can build. While human concepts, just as words used in linguistic communication, can be *decoupled* (used regardless of the presence of the referent in the environment or of any intention to action), it is not clear that this is the case for animal concepts.

Here, one possible domain of interest is so-called *mental time travel* (see Suddendorf, and Corballis 2007), a notion that covers both episodic memory (memory for specific past events and the associated emotions and feelings) and projection into the future. Clearly, given that it concerns past or future events or situations, mental time travel has to deploy concepts for entities that are not present in the environment of the thinker. The question of whether nonhuman animals have mental time travel or not (for a positive argument, see Corballis 2013, for a negative one, see Suddendorf 2013) is thus relevant to a potential difference of nature between human and nonhuman concepts. Clearly, human capacities for mental time travel are wide ranging far beyond animal capacities (distance in time is not strongly limited in humans, while it seems to be in animals, where a few days is the limit). But beyond the distance in time limitations, there seems to be other differences. Up to now, the only evidence regarding episodic memory in animals is relative to food hiding. Regarding projection into the future it has to do with planning (e.g. chimpanzees taking with them hammer and anvil when they go to eat nuts). A good example of so-called "spontaneous planning" is given in Osvath (2009) who describes how the alpha male of a chimpanzee group in a zoo would make caches of stones that he would throw at zoo visitors the next day. But in all of these examples, while concepts may be deployed in absentia, they are strongly linked to an intention for action. In other words, they are not deployed in the disinterested way of which Millikan (2013) rightly argues that it is a central characteristic of human thought. Additionally, when an animal engaged in an animal language program refers to an absent object, it is always in a request for that object (see, e.g. Segerdhal, Fields, and Savage-Rumbaugh 2005). Indeed, it has been noted (see, e.g. Cheney and Seyfarth 1990) that animal communicative acts do not take into account the informational state of the audience. Apparently, they are not informative, but directive acts. Thus, there

seems to be an entire lack of transmission of information for anything other than practical purposes both in naturally occurring animal communication and in communication in animal language programs. This suggests that either the nature of concepts or the way in which they are deployed (or, presumably, both) are different in human and nonhuman animals. While there is a limited form of decoupling in at least some animal species, it is a weak decoupling in which concepts can be deployed in absentia, but only in representations linked to actions. By contrast, human concepts are strongly decoupled in the sense that they can be deployed not only in absentia but independently of actual, potential, or future action.

While this is not the place to give a detailed account of human concepts (see Reboul 2017), there is one interesting example, which is color concepts. On the face of it, colors being so-called secondary qualities (see Locke 1975), they seem to be the epitome of a visual concept, a concept that would depend for its very existence on visual experience.[5] Yet, as was pointed out by Milligan (see Magee and Milligan 1995), even people blind from birth can use and deploy color concepts, in the sense that they can amass (and transmit) information about colors. This is possible because humans (and presumably only humans) have *deferential concepts*, concepts that are not based on direct knowledge of their referents, but on knowledge "borrowed" from "experts" (see Fodor 1975). And this, in turn, is possible because human linguistic communication allows humans to communicate about entities that can be absent or inaccessible to perception. There is however an hen-egg problem here: Do we have deferential concepts because we have decoupling in language or do we have decoupling in language because we have decoupling in concepts? The first possibility would imply that decoupling (both in language and in concepts) depends on the interface between the FLN and the motor-articulatory system. The second would imply that decoupling in language depends on the interface between the FLN and the intentional conceptual system. While one can argue for the first hypothesis by appealing for instance to Dennett's (2017) notion of language as a *cognitive crane*, it is not clear why externalization as such would allow humans and only humans to decouple language and concepts. After all, the few animal signals that are referential are not decoupled (see Cheney and Seyfarth 1990), so externalization is clearly not enough for decoupling. Additionally, when provided with such an externalization, animals engaged in animal language programs do not thereby become able of decoupling, as shown by their communicative acts. And finally, this hypothesis fails to explain the limitations in their vocabularies.

Let us come back to this point. As noted above, explanations in terms of memory limitations are unsatisfactory because it has been shown that animals (primates, dogs, and pigeons) can learn more than a thousand arbitrary associations, much in excess of the vocabularies attained in animal language programs. But what is it exactly that these animals learnt? In a study by Fagot and Cook (2006), the subjects (baboons and pigeons) learnt arbitrary associations between pictures and one or the other of two colors. Pigeons learnt between 800 and 1200 such associations and baboons between 3500 and 5000. In Kaminsky, Call, and Fischer's (2004) study, a border collie learnt around 200 associations between linguistic expressions (e.g. "the blue ball") and individual objects. Finally, in Pilley and Reid's (2011) study, Chaser, a female border collie mastered 1022 "names" for different objects, all toys, over the course of three years, before the study was discontinued, leaving open the possibility that she might have done even better with a longer time. This achievement is intriguing, in light of the limitations of chimpanzees's vocabularies in animal language programs.

What is it exactly that Chaser learnt? She learned something like proper names for individual objects, that is, associations between auditory forms and individual objects. By contrast, animals engaged in animal language programs learned (very laboriously) associations between forms (abstract visual symbols or gestures) and categories of objects, something clearly more demanding from a cognitive point of view. While Pilley and Reid (2011) claimed that Chaser also learnt three common names (*balls, frisbees,* and *toys*), it is not clear that she actually learnt *toys* as a superordinate category for both balls and frisbees (for a discussion, see Reboul 2017). So, all in all, Chaser learned a great number of proper names, but only two common names. All of this suggests that what is important in acquiring a lexicon is not so much the ability to learn new associations, but rather, the ability to categorize objects on the fly (to conceptualize), the resulting categories (or concepts) being then associated with forms, whether these are acoustic, gestural, or visual.

Do we have any indications that human and nonhuman animals have different conceptualizing abilities? The first relevant factor is obviously lexical acquisition, which is fast, seems painless, and is unlimited in human children, while it is slow, laborious, and limited in other animal species. Beyond that, it seems that the human perceptual (and notably visual) system is geared toward abstraction in a way that animal perception is not (see Reboul 2017). For instance, the human preference for the treatment of visual information at a global rather than a local level may be linked to the ease with which humans master basic categories (see Rosch et al. 1976 and for a general discussion, Reboul 2017). Finally, and crucially, the very nature of the concepts acquired may be different.

I have already suggested above that this may be the case: animal concepts seem linked to actual, potential, or future action in a way that human concepts are not.

30.3.3 Affordances

To pinpoint the difference, the notion of *affordance* introduced by Gibson (1986) in his ecological theory of visual perception is interesting. Gibson's view was that a visual scene is perceived by a given organism in terms of the potentialities for action that it makes available to this organism and that (some of) the objects in the scene are categorized accordingly (as potentialities for action, i.e. as affordances). On such a view, the same visual scene will offer different affordances to different species, but also to a single organism at different times depending on its current biological status. Now, clearly, the notion of affordance has a strong adaptive flavor: natural selection determines, at least in part, what affordances are for a given organism, because affordances are important for survival. This does not mean that some affordances cannot be learnt, for instance through association, but one would expect a number of affordances to be genetically inherited (see New, Cosmides, and Tooby 2007 for a nice experimental demonstration of this). Beyond the adaptative aspect, what is central to the notion of affordances is the idea of a direct link between (visual) categorization and action. This direct link between categorization and action is precisely what seems to characterize animal concepts relative to human concepts.

Clearly, the claim is not that humans do not have affordance categorization. Given the adaptive impact of affordances, it seems safe to postulate that if affordance categorization exists, it will be widespread among species. Rather, it is that in humans, and as far as we know, only in humans, concepts are not limited to affordances. Side by

side with affordance categories, humans are able to develop a much richer conceptual apparatus, in part independent of visual perception as the possibility of decoupling manifest in deferential concepts as well as the existence of abstract concepts show. And this is presumably the explanation for the very different lexicon sizes that are manifested by humans and by animals engaged in animal language programs. Thus, a natural conclusion would be that the strong decoupling that characterizes human linguistic communication is due to the interface between the FLN (merge, in other words) and the conceptual-intentional system, rather than to its interaction with the sensory-motor system.

30.4 Conclusion: Extending the FLN

Thus, it seems that the core of human language is the interface between the FLN (merge) and the conceptual-intentional system. Additionally, there are good reasons to believe that the human conceptual-intentional system is specific to humans in the sense that human concepts can be deployed independently of actual or potential action (they are strongly decoupled), while this is not the case for animal concepts. This suggests that it might make sense to extend the FLN in such a way that it is composed of both Merge and the conceptual-intentional system. This, it should be noted, echoes Chomsky's view that language is primarily a tool for thought.

Such a move would also open new possibilities for research on language evolution. First, it means that it is not only recursion but also decoupling that should be investigated in comparative psychology. As said above, chimpanzees seem to be able of planning, manifesting a weak kind of decoupling, and investigating the scope and the limits of decoupling in other primate and non-primate species might be interesting.

Second, investigations of the interface between Merge and the conceptual-intentional system would be rewarding. This could be done from a more syntactic point of view, as in the exo-skeletal model proposed by Borer (2005a, 2005b, 2013). It could also be done from a pragmatic point of view. Chomsky (2006) argued that meaning is largely a matter of pragmatics rather than of "externalist" semantics. Contemporary pragmatics, notably of the relevance-theoretic variety, centers on conceptual matters (the so-called lexical pragmatics approach, see Carston 2002, as well as Wilson and Carston 2007, and Allott and Wilson, Chapter 27, this volume) and has advocated an immediate pragmatic interpretation, rather than a pragmatic interpretation mediated by a primary semantic interpretation. This would seem to be an area of profitable investigation regarding the evolution of the Faculty of Language if the FLN is extended to include both Merge and the conceptual-intentional system.

Endnotes

1 Previously, generative grammar had distinguished between *performance* and *competence*. While the two distinctions are not equivalent, they are related: what is paramount is inner representation versus external productiom.

2 Quotations and references to pages will be given relative to the 2010 reprint in Larson, Déprez and Hiroko (2010).

3 Hockett (1959) used "displacement" or "displaced reference," but the term "decoupling" has been extensively used in the psychology of early symbolic activity in young children and has the advantage of targeting cognitive ability beyond communication (see, e.g. Nichols and Stich 2000).
4 This excludes the honeybee dance, whereby a bee inside the beehive indicates the location of nectar outside of the hive to the other bees. It is clearly not decoupled in the strong sense.
5 This was confirmed by the World Color Survey (see Kay et al. 2011), which demonstrated that despite lexical diversity, color centroids are remarkably stable among human populations and dependent on the human visual apparatus.

References

Anderson, S. 2004. *Doctor's Dolittle's Delusion: Animals and the Uniqueness of Human Language*. New Haven and London: Yale University Press.

Bickerton, D. 2009. *Adam's Tongue: How Humans Made Language: How Language Made Humans*. New York: Hill & Wang.

Bloom, P. 2000. *How Children Learn the Meaning of Words*. Cambridge: MIT Press.

Borer, H. 2005a. In *Name Only*. Oxford: Oxford University Press.

Borer, H. 2005b. *The Normal Course of Events*. Oxford: Oxford University Press.

Borer, H. 2013. *Taking Form*. Oxford: Oxford University Press.

Byrne, R., and A. Whiten, eds. 1988. *Machiavellian Intelligence: Social Expertise and the Evolution of Intellect in Monkeys, Apes and Humans*. Oxford: Clarendon Press.

Carston, R. 2002. *Thoughts and Utterances: The Pragmatics of Explicit Communication*. Oxford: Blackwell Publishing.

Cheney, D., and R. Seyfarth. 1990. *How Monkeys See the World: Inside the Mind of Another Species*. Chicago: Chicago University Press.

Chomsky, N. 1986. *Knowledge of Language: Its Nature, Origin and Use. Westport, CT*: Praeger.

Chomsky, N. 2006. *New Horizons in the Study of Language and Mind*. Cambridge: Cambridge University Press.

Chomsky, N. 2010. Some simple evo-devo theses: How true might they be for language? In *The Evolution of Human Language: Biolinguistic Perspectives*, edited by R. Larson, V. Déprez, and Y. Hiroko, 45-62. Cambridge: Cambridge University Press.

Chomsky, N. 2015. The Minimalist Program. 20th Anniversary Edition. Cambridge: The MIT Press. (1st edition: 1995).

Chomsky, N. 2016. *What Kind of Creatures Are We?* New York: Columbia University Press.

Christiansen, M., and N. Chater. 2016. Creating Language: Integrating Evolution, *Acquisition and Processing*. Cambridge: The MIT press.

Corballis, M. 2013. Mental time travel: A case for evolutionary continuity. *Trends in Cognitive Sciences*, 17/1: 5–6. DOI:10.1016/j.tics.2012.10.009

Dennett, D. 2017. *From Bacteria to Bach and Back: The Evolution of Minds*. New York/London: W. W. Norton & Company.

Fagot, J., and R. Cook. 2006. Evidence for large long-term memory capacities in baboons and pigeons and its implications for learning and the evolution of cognition. *Proceedings of the National Academy of Science* 103/46: 17564–7.

Fitch, T., M. Hauser, and N. Chomsky 2005. The evolution of the Language Faculty: Clarifications and implications. *Cognition* 97: 179–210.

Fodor, J. 1995. *The Elm and the Expert: Mentalese and Its Semantics*. Cambridge: The MIT Press.

Gibson, J. 1986. *The Ecological Approach to Visual Perception*. Hillsdale, NJ: Lawrence Erlbaum.

Gould, S., and E. Vrba. 1982. Exaptation: A missing term in the science of form. *Paleobiology* 8: 4–15.

Hauser, M., N. Chomsky, and T. Fitch. 2010. The Faculty of Language: What it is, who has it, and how did it evolve? In *The Evolution of Human Language: Biolinguistic Perspectives, edited by R. Larson, V. Déprez, and Y. Hiroko, 14–41. Cambridge: Cambridge University Press. Initially published in Science* (2002), 298: 1569–1579.

Hockett, C. 1959. Animal "Languages" and human language. *Human Biology* 31/1: 32–39.

Kaminski, J., J. Call, and J. Fischer. 2004. *Word learning in a domestic dog: Evidence for "Fast Mapping." Science* 304: 1682–1683.

Kay, P., B. Berlin, L. Maffi, W. Merrifield, and R. Cook. 2011. *The World Color Survey*. Berkeley: Center for the Study of Language and Information.

Krebs, J., and R. Dawkins. 1984. Animal signals: Mind-reading and manipulation. In *Behavioural Ecology: An Evolutionary Approach*, edited by J. Krebs and N. Davies, 380–402. Sunderland, MA: Sinauer Associates.

Lenneberg, E. 1967. The biological foundations of language. *Hospital Practice* 2/12: 59–67.

Locke, J. 1975. *An Essay Concerning Human Understanding*. New York: Oxford University Press.

Magee, B. and M. Milligan. 1995. *On Blindness: Letters between Bryan Magee and Martin Milligan*. Oxford: Oxford University Press.

Millikan, R. 2013. Natural information, intentional signs and animal communication. In Animal Communication Theory: Information and Influence, edited by Ulrich. E. Stegmann, 3313–3603. Cambridge: Cambridge University Press (Kindle edition).

New, J., L. Cosmides, and J. Tooby. 2007. Category-specific attention for animals reflects ancestral priorities, not expertise. *Proceedings of the National Academy of Science* 104/42: 16598–16603.

Nichols, S., and S. Stich. 2000. A cognitive theory of pretense. *Cognition* 74: 115–147.

Osvath, M. 2009. Spontaneous planning for future stone throwing by a male chimpanzee. *Current Biology* 19/5: R190-1.

Pilley, J., and A. Reid. 2011. Border collie comprehends object names as verbal referents. *Behavioural Processes* 86/2: 184–195. DOI:10.1016/j.beproc.2010.11.007.

Pinker, S., and P. Bloom. 1990. Natural. Behavioral and Brain Sciences 13/4: 707–727. language and natural selection.

Pinker, S. and R. Jackendoff. 2005. The nature of the language faculty and its implications for the evolution of language (Reply to Fitch, Hauser, and Chomsky). *Cognition* 97: 211–225.

Reboul, A. 2017. *Cognition and Communication in the Evolution of Language*. Oxford: Oxford University Press.

Rosch, E., C. Mervis, W. Gray, D. Johnson, and P. Boyes-Braem. 1976. Basic objects in natural categories. *Cognitive Psychology* 8/3: 382–439.

Searcy, W., and S. Nowicki. 2005. *The Evolution of Animal Communication: Reliability and Deception in Signaling Systems*. Princeton: Princeton University Press.

Segerdhal, P., W. Fields, and S. Savage-Rumbaugh. 2005. *Kanzi's Primal Language: The Cultural Initiation of Primates into Language*. Basingstoke and New York: Palgrave Macmillan.

Suddendorf, T. 2013. Mental time travel: Continuities and discontinuities. *Trends in Cognitive Sciences* 17/4: 151-152. DOI:10.1016/j.tics.2013.01.011

Suddendorf, T. and M. Corballis. 2007. The evolution of foresight: What is mental time travel and is it unique to humans? *Behavioural and Brain Sciences* 30/3: 299–313.

Tomasello, M. 2010. *Origins of Human Communication*. Cambridge: MIT Press.

Tomasello, M. 2014. *A Natural History of Human Thinking*. Cambridge: MIT Press.

Whiten, A., and R. Byrne, eds. 1997. *Machiavellian Intelligence II: Extensions and Evaluations*. Cambridge and New York: Cambridge University Press.

Wilson, D. and R. Carston. 2007. A unitary approach to lexical pragmatics: relevance, inference and ad hoc concepts. In *Pragmatics*, edited by N. Burton-Roberts, 230–259. Basingstoke: Palgrave.

31

Chomsky and Intentionality

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31.1 Introduction

A nearly ubiquitous term in generative linguistics and most cognitive science is "(mental) representation."[1] *Prima facie*, a representation must be a representation of something, whether real (e.g. New York) or not (e.g. Zeus). "Intentional(ity)" is the term given to this general property of representations and many mental states more generally.[2] Thus, one may have beliefs, desires, hypotheses, and mental representation that are *of* or *about* chairs, cats, numbers, ghosts and heaven and hell. This isn't merely a feature of ordinary thought and talk. In empirical psychology, the processes of vision are said to involve representations *of* objects, colors and shapes, and, in linguistics, representations *of* sentences, phrases and words and the like, whether or not there actually are such things in the ambient environment.

The nineteenth-century German-Austrian philosopher Franz Brentano (1874/1973) resurrected the notion of intentionality from medieval philosophy and advanced two interesting theses about it: (i) that intentionality was "a distinguishing feature of all mental phenomena," and (ii) that "no physical phenomenon exhibits anything similar" (p. 97). This last – standardly expressed as "the irreducibility of the intentional" to physical terms – is what is usually referred to as "Brentano's thesis", and has been vigorously discussed by philosophers such as Chisholm (1957), Quine (1960/2013), and Fodor (1987b). However, for all the ubiquity of talk of "representations" in Chomsky's work, the role of intentionality in it is seldom even mentioned. From at least the time of his (1959/64) review of Skinner, Chomsky presented his work as reviving "mentalism" as against the then-dominant behaviorism, and we suspect that most readers have presumed that this revival included intentionality. It therefore might have come as a surprise to many that Chomsky should abjure the notion in various essays written in the 1990s that were gathered together in his (2000) without having voiced

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such leeriness throughout the previous 40 years. Rey (2003b; 2008, and 2020) and Collins (2003, 2007, 2014) discussed this development in exchanges, some of which the present article will summarize, along with related discussions in Matthews (1980, 2006), Egan (1992, 2014) and Adger (2019).

As our exchanges attest, the present authors have somewhat different views on the matter. The present discussion will distill the various disagreements between ourselves and others to deliver a "common coin" problem concerning the position of linguistic competence within the mind more broadly. Roughly, intentional representations appear to be the currency with which the language faculty engages with other components of the mind, and so intentionality appears to be fundamental to our broader understanding of the linguistic mind, even if we might dispense with intentional attributions when thinking more locally about the faculty of syntax in itself. The problem doesn't decisively militate for a basic role for intentionality in our understanding of linguistic theory, but it does put the issue on a footing that should be acceptable to all and should invite further reflection and inquiry.

In what follows, we will set out some basic, often puzzling features of intentionality (Section 31.2), with an eye to its role not so much in ordinary folk ascriptions but in serious psychological explanations (Section 31.3), especially in many of Chomsky's own presentations of his theory (Section 31.4). But we will then consider Chomsky's censure of the notion, leading him to *deny* what would seem to be the explicit intentionalisms on which he seems to rely (Section 31.5). This tension may, however, only be superficial (Section 31.6); at least as concerns the language faculty alone, the "representation of" idiom used by Chomsky might be understood in nonintentional terms (Section 31.7). Two initial problems with such a construal can be set aside (Section 31.8). However, a third – what we call "the common coin" problem – is more serious (Section 31.9).

31.2 Intentionality

Let us assume, first off, that the home of intentionality is with such phenomena as representations and propositional attitudes,[3] including perceptions. Their intentionality is characterizable by at least the following five features:[4]

(i) *"Aboutness" or "intentional content"*: e.g. attitudes/representations can be about/of objects, people, words, syllables, numbers, ghosts – anything one can think of.

(ii) *"Aspect"*: Seeing, hearing, representing something standardly involve doing so with respect to *one aspect* of the object *rather than another*. One might see a speck of light as merely a speck of light, or as the morning vs. evening star; think of Zeus as a god or a rogue; or hear a noise as merely noise, or as a word, and/or as the main verb of a sentence.

(iii) *Answerability*: attitudes/representations can be assessed in terms of their truth or falsity, or accuracy or inaccuracy, and thus are "answerable" to whether the world is as they represent it to be. One person may, for example, rightly or wrongly hear someone as having uttered a word.

(iv) *Lack of existential commitment*: attitudes/representations can be about things that don't exist, and may even be impossible, as when one entertains representations of ghosts, illusory triangles or posits of false scientific theories, as in the case of phlogiston and the ether.

While it is convenient to introduce intentional terms via our familiar, "folk" mentalistic idiom of propositional attitudes, the bare notion isn't essentially dependent on any such framework. One might reckon explanations pitched at the level of what an agent believes and desires to be too interest-relative or "folksy" to feature in proper science. However, serious scientific laws and generalizations regarding mental processes appear to be up to their necks in intentionality, as in the case of research into e.g., psychophysics (e.g., what looks/sounds brighter/louder than what), perception (e.g., visual illusions), animal navigation, patterns of (fallacious) reasoning, memory, emotions and psycholinguistics (how people hear and produce noises as language) and children's understanding of minds. It isn't that intentionality has proven to be a kosher notion because of its apparent ubiquity; the point, rather, is that intentionality cannot be summarily dismissed as too "folksy" unless one is willing to dismiss all this work and more, or provide alternative explanations without appealing to it.

Of course, behaviorists precisely sought to limit the mind to complex dispositions that don't trade in representational or intentional states. The leading philosophical proponent of behaviorism, Quine (1960/2013) famously wrote:

> One may accept the Brentano thesis as either showing the indispensability of intentional idioms and the importance of an independent science of intention, or showing the baselessness of the intentional idiom and the emptiness of a science of intention. My attitude, unlike Brentano's, is the second. (Quine 1960/2013, p. 221)

He accords intentional talk at best a pragmatic status, allowing that, though it's not strictly part of science, it's indispensable in ordinary life. Such a view is developed by other philosophers such as Davidson, Putnam and Nagel, all of whom Chomsky dubs "methodological dualists," for suggesting that the mental can't be treated by the usual methods of empirical science.[5]

One might reasonably think that rejecting behaviorism in favor of cognitive science is of a piece with taking intentional states seriously in a proper science of the mind. Such, at any rate, is how the revolution in linguistics initiated by Chomsky has appeared to many, an appearance we'll be examining in this entry.

31.3 Chomsky's (Apparent) Intentionalism

Chomsky doesn't explicitly address issues of intentionality one way or another in his purely technical writings; and he actually seldom addresses it in any detail in his more general, meta-theoretic ones. The present authors disagree about how to understand at least Chomsky's pre-1990 writings, where he became more explicit. In this section, GR will discuss an intentionalist reading of them; in Sections 31.6–8, JC will present a nonintentionalist reading. In Section 31.9 we will consider whether a Chomskyan theory itself requires intentionality, whether or not Chomsky ever thought it did.

Throughout his writings, Chomsky often characterizes his proposals in what would seem to be a *prima facie* intentional vocabulary. In the (1975a) introduction to the publication of *The Logical Structure of Linguistic Theory* (1955/1975), for example, he writes:

> The construction of a grammar … by a linguist is in some respects analogous to the acquisition of language by a child … The child constructs a mental representation of the grammar of the language … The child must also select among the grammars compatible with the data. (Chomsky 1975a, p. 11)

Indeed, in his (1965) *Aspects of the Theory of Syntax*, Chomsky's proposal for language acquisition seemed to be an application of Hempel's (1962) "deductive-nomological model" of scientific explanation (we italicize the apparent intentionalisms):

> (ATS) A child who is capable of language learning must have:
>
> (i) a technique for *representing* input signals;
> (ii) a way of *representing* the structural information about these signals;
> (iii) some initial delimitation of a class of possible *hypotheses about* language structure;
> (iv) a method for determining what each such hypothesis *implies* with respect to each sentence;
> (v) a method for selecting one of the (presumably, infinitely many) hypotheses that are allowed by (iii) and are compatible with the given primary linguistic data. (Chomsky 1965, p. 30)

Another way in which intentional commitment would seem to surface is in Chomsky's explicit advocacy of a computational perspective on cognition. In his (1980a) *Rules and Representations*, for example, he claims that people

> cognize grammar that constitutes the current state of our language faculty and the rules of this system as well as the principles that given their operation … [where] cognizing has the structure and character of knowledge but may be and in interesting cases is inaccessible to consciousness . . . . (Chomsky 1980, pp. 69–70; see also 1986, p. 265)

What is particularly striking here is the contrast he then proceeds to draw between a "non-cognizing missile that acts in accord with laws governing the orbit of the moon" and a "cognizing missile that computes its trajectory by reference to a representation of these laws," the latter (abstracting from its specific task-orientation) serving as a model for a normal speaker's understanding of language (1980, pp. 102–103, 275n61). Specifically, the cognizing missile:

> incorporates an explicit theory of the motions of the heavenly bodies and information about its position and velocity and that carries out measurements and computations using its internalized theory to adjust its course as it proceeds. … In [this] case … inquiry might lead us to attribute to the missile something like a "mental state" … postulating a system which involves the cognizing of certain principles and computation involving those principles and certain representations. (Chomsky 1980, p. 103, emphasis added).

One way to appreciate just how intentionalist such a missile would have to be is to imagine that the "internalized theory" and information about its position is actually false, leading the machine systematically astray. In such a case, we would appear to be obliged to ascribe to it (mis-)representations of the domain, which would, moreover, explain further computations it might deploy to "correct" itself.

We could cite many more examples (see Rey 2003b, and 2020:sec 8). Suffice it to say that, for Chomsky, both language acquisition and mature competence at least *appear* to be intentional processes and states insofar as both depend for their explanation upon a theory that credits some kind of informational content to the states rather than treating them as merely mechanical or physical transitions. They are states and transitions that are sensitive to what is represented by them, and not merely physically individuated in terms of, say, physical properties of brains (we'll return to this issue in Section 31.9).

31.4 Chomsky's Censure of the Intentional

For all his use of apparently intentional vocabulary, however, Chomsky (2000) explicitly renounces an intentional understanding of *any* proposals in cognitive science!:[6]

> If "cognitive science" is taken to be concerned with intentional attribution, it may turn out to be an interesting pursuit (as literature is) but is not likely to provide explanatory theory or to be integrated into the natural sciences. (Chomsky 2000, p. 23)

Indeed, Chomsky appears to embrace precisely the same pragmatic conception of intentionality that was advocated by behaviorists and other "methodological dualists." In passages that echo the passage of Quine that we quoted above, Chomsky writes:

> [I]ntentional phenomena relate to people and what they do as viewed from the standpoint of human interests and unreflective thought, and thus will not (so viewed) fall within naturalistic theory, which seeks to set such factors aside. (Chomsky 2000, 22–23; see also p. 132)

Further:

> We can be reasonably confident that "mentalistic talk" will find no place in attempts to describe and explain the world. (Chomsky 1996, pp. 45–47)

31.5 Only an Apparent Inconsistency?

Perhaps Chomsky simply changed his mind sometime between writing the above and the earlier passages. Many of the relevant earlier writings, however, bear a closer look. For instance, Chomsky (1959/64) writes:

> It is reasonable to regard the grammar of a language L ideally as a mechanism that provides an *enumeration* of the sentences of L in something like the way in which a deductive theory gives an enumeration of a set of *theorems*. (Chomsky 1959/64, p. 576, emphasis added).

Similarly, from *Aspects* (1965):

> It seems plain that language acquisition is based on the child's discovery of what *from a formal point of view* is a deep and abstract theory –a generative grammar for his language … (Chomsky 1965, p. 58, emphasis added)

That is, what seems to concern Chomsky here isn't a theory or mechanism characterized intentionalistically, but one that might be characterized merely in terms of *the formal character* of such a theory, as when in logic one can provide a formally specified "proof" theory in abstraction from semantic "models." Arguably, what concerned Chomsky in his (1959/64) criticism of Skinnerian behaviorism was its disregard of *internal formal processes*, not what Chomsky regarded as Skinner's own implicit deployment of *folk intentional talk*, which he argued was (at least in Skinner's hands) essentially empty.

One of us thinks that this kind of interpretation can go some distance towards rescuing Chomsky from apparent inconsistency (see Collins, 2007). Moreover, it bears emphasis that developments within generative linguistics made intentional attribution of a grammar less natural. The so-called Principles and Parameters model developed in the late 1970s views each acquired language as a set of choices (on/off) on a range of open parameters governed by general principles. Language variation thus becomes a matter of parametric variation (e.g. whether a sentence needs a subject). Thus, on this view, the language-acquiring child need not represent the principles at all, much less engage in hypothesis confirmation of them, but need only have the open parameters set. This suggests, although does not entail, a triggering conception of acquisition (cf. Chomsky 1981), whereby the presence of crucial data simply flips a switch. Much controversy remains, both about the P&P model, and how parameters might be set (see Sheehan, Chapter 11 this volume), and we'll return in Section 31.9 to the question of whether it actually does promise a purely "mechanical" conception of language acquisition.

But, putting aside acquisition, this kind of charitable construal won't go all the way to rescuing Chomsky from inconsistency; for at the core of Chomsky's approach is the idea that the linguistically competent agent *represents* what from the theorist's perspective are perhaps not rules, but at least abstract grammatical structures to which the principles apply. *Represent* is a transitive verb, and *representation* standardly takes a prepositional phrase complement, "of *x*" (a verb, phonological feature), and would seem to involve the above-mentioned properties of intentionality.[7]

It's important to note that no advance on this question is made by the perfectly apt observation that representation needn't be construed externally. Chomsky (2000) seems insensitive to this point. He claims, for example, that, in the case of the representations he's appealing to in linguistics:

> we need not ponder what is represented, seeking some objective construction from sounds or things. The representations are postulated entities, to be understood in the manner of *a mental image of a rotating cube*, whether it be the result of tachistoscopic presentations of a real rotating cube or stimulation of the retina in some other way; or imagined, for that matter. (Chomsky 2000, p. 160; emphasis added)

But, again, intentional representations may represent things that aren't real.[8] This holds trivially for expectations about Father Christmas, but also, apparently, for a visual system that represents Euclidean solids (which *can't* exist in the physical world). Similarly, we might think of the language system as representing the merging of two linguistic items, and, due to its features, targeting one for movement into some other structural position. None of this commits us to the actual existence of those items in the acoustic stream. So we might well ponder "what is represented" by a representation in such cases, or in the case of a cube when there is no cube.[9]

31.6 The Language Faculty Alone

Implicit in Chomsky's treatment of grammar is the idea that the positing of the language faculty offers an "abstract" perspective on a physical system (the human brain) that implements the relevant features of the *abstracta* in ways we currently don't understand. Developing this view, we might think of its various technology as abstract posits, in the way one might regard, say, "point masses" as abstract posits in Newtonian mechanics. The question is how do these posits of the theory relate to the speaker-hearer? We can, of course, say that the speaker–hearer represents the posits in a subconscious fashion and that the dynamics of the theory (how the posits relate to one another according to the principles of the theory) amount to computations defined over the content of what is represented, much as a program operates by being implemented in hardware.

Here's an alternative perspective. Instead of thinking of the posits of the theory as being represented by speaker–hearers, we could think of the posits as merely a means of *categorizing* states of the speaker-hearer in ways that the theory tracks or models. In this sense, the theorist describes the formal, neural mechanisms in terms of the abstract model, but doesn't presume that speakers themselves represent the model. The unknown mechanisms of the speaker–hearer are tracked by the kind of inferences the theory mandates.

This proposal is aligned with a long-standing ambiguity in Chomsky (1965, 1980a) between the perspective of the speaker–hearer and the perspective of the theorist. In terms of an analogy advanced by Matthews (2010) for cognitive science generally, propositional attitude ascriptions can be viewed as like the ascriptions of number to physical magnitudes: just as the mass of the moon may be described by using a number without the moon representing it, so might an agent's attitudes be described by a system or propositions that the agent needn't represent. Similar proposals have been defended by Paul Churchland (1979) and, with respect to vision theory, by Frances Egan (1992), who expressed a view Chomsky (2000, pp. 162, 203n9) explicitly endorsed.

Thus, we can think of "representation of *x*" as theoretically employable in two ways. Employed by the theorist, the relation is intentional insofar as abstract posits and relations between them are theoretically employed to describe and explain the relevant phenomena. There is another construal, however, which we can notate as "representation-of-*x*" or simply "*x*-representation." Here, *x*'s aren't contents of representations, but ways of distinguishing one representation from another via the relevant theoretical vocabulary, where the representations aren't *of* anything, but merely pick out, in an abstract fashion, unknown physical states that act in ways the theory tracks. The "of" phrase is merely *classificatory*. The notational device of hyphenating representational idioms was due to Chomsky's mentor, Nelson Goodman (1949) who suggested talking of a "*cube*-picture," instead of "a picture of a cube." Here we seem to have a way of construing "representation of" without any commitment to problematic intentional entities that they are "of."

One might worry that just classifying something as, e.g., a cube-representation would still require mention of someone's *intention to produce* such a representation. But at least in the case of linguistic items, it might reasonably be supposed that the mere functional role of, e.g., a noun- or verb-representation in the internal grammar would suffice: thus, a verb-representation, unlike a noun representation, might play the role of generating VP-representations that take NP-representations and CP-representations as

complements, without the need of any intentional state. Of course, *theorists* will need to state the *theoretical generalizations* by dropping the "-representation" suffix and talking about, e.g. verbs, VPs and complements, but, per the above proposal, they may do this without supposing the speaker need do so.

31.7 Two Problems and Their Potential Resolution

Two initial problems might be raised for this picture, one regarding inference and the other, generalization. The inference problem is easily stated. If speaker–hearers don't represent the contents the theorist posits, then they cannot perform inferences over such contents, and yet the theory precisely gains its explanatory power by crediting speaker–hearers as, in some sense, performing inferences over the contents. For example, it's because a speaker–hearer represents a structure as $[_{CP} \ldots [_{VP}$ *love* $[_{NP}$ *who*]]] that she can derive the "correct" interrogative structure $[_{CP}$ *who* … $[_{VP}$ *love* $[_{NP}$ *who*]]], with the lower copy of *who* unpronounced. In line with the proposal, however, we may foreswear any attribution of inference or derivation to the agent. The theory is deductive or inferential, but *what it models* are various systematic relations between structures, each of which explain various features of the agent's competence with the relevant linguistic material. How the agent's brain *realizes* or *implements* such relations isn't the theory's business, at least not in our current state of ignorance (cf. Poeppel 2012; Collins 2014).

Essentially the same reasoning applies to the second problem of generalization. As theorists, we make generalizations about linguistic structures, such as when movement is possible, or how PRO must be interpreted, and attribute them to the agent. If we depict agents as only realizing *x*-representations, however, then they cannot make any generalization over *x* to arrive at some generalization as to what can be represented. Again, we may forswear agents themselves actually making any generalization. What our generalizations capture are the basic properties of the system, but possessors of the system needn't themselves represent such generalizations or properties (cf. Poeppel 2012; Collins 2014).

The proposed model is effectively saying that theorists track states and generalizations of the linguistic system in an explicitly representational format, but what the theory is true of needn't have such representational properties. We simply don't know how the system cleaves to the kind of properties our theories encode, but our theories remain explanatory so long as linguistic agents do enter into states and processes that are sensitive to the information regarding grammatical structure that our theories posit.

All of this might seem to be an overly gymnastic stratagem to avoid the natural move of simply crediting the relevant intentional contents to the agent and so allowing her to make inferences and generalizations of the kind the theorist makes explicit. Two responses might be offered.

First, recall that we are now in the business of seeing if some non-intentional conception of representation is possible. If so, we can then consider its relative plausibility in comparison to other models. Secondly, and correlatively, as far as representation of an internal syntax is concerned, it is at least arguable that the view offered is superior to one that simply credits whatever the theorist posits to the agent as represented content. As we saw, there's a good sense in which we don't want to say that an agent performs

inferences or generalizations over contents. Instead, their competence simply *realizes* properties that our inferences and generalizations capture. It bears emphasis that this kind of relation between theory and its object is perfectly general, and so should prevail when we turn to cognition generally (see Matthews, 2010).

However, even if the above recommendations are accepted, a significant worry remains for a non-intentional approach to representation, which we earlier advertised as "the common coin" problem.

31.8 The Need of Intentionality as a Common Coin

By "a common coin" we mean to abbreviate a point Chomsky often stresses about the relation of a grammar to other mental systems. For example, in his (1995) he writes:

> … The information provided by [the I-language] has to be accommodated to the human sensory and motor apparatus. Hence, UG must provide for a phonological component that converts the objects generated by the [I-language] to a form these "external" systems can use. (Chomsky 1995, p. 221; see also 2004, p. 3; and 2016, p. 8)

He calls the conditions so mandated, *legibility conditions:*

> These output conditions are legibility conditions, in the sense that other systems must be able to "read" the expressions of the language and use them as "instructions" for thought and action. (Chomsky 2000, p. 9)

Just what these legibility conditions amount to remains open to inquiry. Minimally, if cognitive systems are to interact at this level of analysis, then they must traffic in, as it were, a common currency that renders at least some information from one system intelligible to the other. Thus, an I-language might be viewed as providing structures that can be interpreted in perception, production, conceptual understanding, communication or in privately entertaining thoughts and goals. Such a condition would seem to be required to fulfill the aim of "explanatory adequacy" (1965, pp. 24–27) as a condition on the kind of grammars that human neonates may come to acquire from exposure to their ambient community. To recall the 1965, p. 30 *Aspects* model quoted in Section 31.4 above, the child must have "a way of *representing* the structural information about the [auditory input] signals," compatibility with which is one basis on which one grammar is selected over another. It isn't clear that the Goodmanesque proposal sketched above could dispense with what would seem to be *this* intentionalist notion of representation, since, at the appropriate computational level of analysis, the systems must share representations (the *x*'s of *x*-representations, as it were).

This common coin problem is most vivid in the realm of linguistic perception and its role in acquisition. As we mentioned in Section 31.6, one of the initial attractions of the Principles and Parameters model of the 1970s was that it would seem that a child's acquisition of a grammar might be less a matter of testing hypotheses and more a matter of triggering a finite number of switches to be on or off. And this would seem to obviate the intentionality that might seem to be required for hypothesis testing: the grammars would seem to be selected on the basis of brute causal processes initiated by the auditory input, which needn't involve any actual "representation of structural information."

There is, however, a fundamental problem with viewing parameter setting in terms of brute triggering. Brains are physical systems, and the only ways in which they can interact with other things in the world is by way of *local, physical properties*, such as a certain electric charge or intensity value in a magnetic field. But if that's so, how can a system like a speaker be sensitive to phenomena that *aren't* local or physical, such as *being a word* or *a phrase*? Imagine that we discovered a plant somewhere that systematically changed it shape in response to someone uttering verb phrases in English? That would be astonishing, and, more importantly, a phenomenon badly in need of explanation. How could a plant possibly exhibit such a sensitivity? What is needed is some kind of systematic connection between the physical and what we might call "abstruse" (nonlocal or nonphysical) properties such as *being a verb phrase*.[10]

Some abstruse sensitivities could, of course, arise from happy correlations between abstruse and proximal physical stimuli, so that, at least across a wide variety conditions, a system could (seem to) exhibit sensitivity to a specific abstruse phenomenon simply by being sensitive to the correlated proximal ones. Thus, being sensitive to certain scents can lead dogs to (seem to be) sensitive to the presence of cadavers, even though, without the scents, the dogs may not be able to distinguish a cadaver from someone asleep; and ants might be sensitive to the relative location of food to their burrow merely by implementing a vector algebra defined on proximal input (Burge 2010, p. 502). It seems unlikely, however, that all abstruse sensitivities are due to such fortuitous correlations.

One way to appreciate the issue is to consider a *transducer*, or any device that transforms a physical magnitude of one form systematically into a physical magnitude of another by virtue of physical laws. Microphones, for example, are transducers that transform sound waves into electromagnetic impulses that other transducers, e.g. amplifiers, can transform back into sound. Animal sense organs consist, at least in part, of just such transducers, transforming, e.g. sound and light waves into electric impulses along visual and auditory nerves.

But abstruse properties, *themselves*, not being physical or local, are patently not transducible. Even if some input/output law, say, the behaviorist's Law of Effect, did provide evidence of a system's sensitivity to grandmothers, it alone would, by itself, explain rather little: we should reasonably want to know *how* that sensitivity could obtain (do grandmother's all have a special look or scent?). The law wouldn't be seriously explanatory of such a sensitivity if there were no account of how a physical system could possibly exhibit it. This is the explanatory challenge raised by people's sensitivity to words and phrases. It's a challenge, we shall argue, that invites intentionality.[11]

Someone might claim that accounting for such sensitivities is a "performance" issue not in the purview of a theory of the I-language. Perhaps. But, as we stressed above, an explanatorily adequate theory of the I-language has to traffic in representations that can satisfy the interface conditions imposed by, *inter alia*, the sensorimotor system, sharing a common coin. After all, "it is only by virtue of its integration into such performance systems that [a] brain state qualifies as a language" (Chomsky 2000, p. 27). Perhaps this integration can be satisfied in some other way. The burden would be on the defender of such a proposal to specify what that way might be.

The linguist is actually presented with two problems. The first is to explain how a child can even be sensitive to phenomena as abstruse as linguistic properties. Mere "triggering" is no explanation unless there is some account about how this triggering could be effected in an essentially local, physical system. The second is why there seems to be a rational, non-arbitrary relation between the grammar the child acquires and the

grammar of the ambient community, as when, say, a child sets the pro-drop parameter in accordance with that community. Jerry Fodor (1998, pp. 128fn28) worried about this problem,[12] and then went on to conclude that

> it may be that … the polemical resources of the hypothesis-testing model have been less than fully appreciated. (Fodor 1998, pp. 128fn8)

So let's turn to back to hypothesis-testing models as a method of acquisition that may have been prematurely abandoned with the advent of P&P models as accounts of the variances and invariances of languages. Intentionality may serve where transduction gives out.

Consider, again, the hypothesis-testing model proposed in Chomsky (1965, p. 30) that he and Halle (1968) also recruited for the specific task of perceiving phonological features:

> The hearer makes use of certain cues and certain expectations to determine the syntactic structure and semantic content of an utterance. Given a hypothesis as to its syntactic structure … he uses the phonological principles that he controls to determine a phonetic shape. The hypothesis will then be accepted if it is not too radically at variance with the acoustic material. (Chomsky and Halle 1968, pp. 24–25)[13]

A natural way to understand this proposal, of course, is that the hearer is sensitive to the abstruse properties of language essentially *by computing the probabilities of hypotheses about them* and/or the degree of fit between postulated and encountered patterns (see Chomsky and Halle 1968, p. 294, and Lidz and Gagliadi 2014, for recent elaboration).

But how does this help? Given that it isn't evident how abstruse linguistic properties can affect a physical system, how can they enter into computations comparing them to acoustics? Turing's model of computation provides the key. It proposes operations on *local, physical representations* – e.g., 0's or 1's written on a tape, or electrical properties of transistors or neurons – that can *represent* those abstruse properties. The computed probabilities are of "hypotheses" that represent, for example, the linguistic properties that are "not too radically at variance with the acoustic material," i.e., imply representations of acoustic phenomena that approximately fit the representations of the input.[14]

A nice question arises about what exactly determines the content of the "hypotheses" that would be selected in this way. This is one of the chief problems of intentionality with which philosophers have been struggling since Quine (1953/1961) showed that a notion of "meaning" is more problematic than people had traditionally thought. This is not the place to consider those struggles. Nor is it crucial to resolve them before regarding intentionality as explanatory.[15] All that is important is to notice that, insofar as explanatory adequacy requires that a child be able to represent auditory input in phonological and other linguistic terms, then what's needed are representations with what we identified in Section 31.3 as the essential features of intentionality, *aboutness*, *aspect*, *answerability*, and *lack of existential commitment*: linguistic representations are *about* items *heard as*, e.g. phonemes, words and sentences, that are *answerable* to a world perceived as containing utterances, *even though those items might not exist*. It's because the output of the syntactic and phonological systems are in this way about the same linguistic phenomena as represented in the perceptual system (and presumably in a uniform format) that the systems are "legible" to one another as Chomsky (2000, p. 9) notes they must be.[16]

A response in the spirit of Chomsky's censure of the intentional idiom might go as follows. Just as representations of a theory of the language faculty pick out as yet unknown physical states of the faculty, so might the representations that relate the faculty to other systems pick out unknown physical transitions at the interfaces. As remarked above, this must in some sense be true, given that any computational processes must be in the end *realized* as physical ones. The issue is how to *characterize* these processes in a way that explains how it is the outputs of *the same I-language* that are perceived, produced, and recruited in thought. We need to say what all those physical processes have *in common*, and it's hard to see any explanatorily viable alternative to it other than the intentional content of the representations over which the physically realized computations are defined.

31.9 Conclusion

Our tentative conclusion is that Chomsky's (2000, 2003) censures of intentionality, although perhaps defensible for a treatment of the language system in relative isolation from other mental systems, doesn't sit well with his requirement that the information provided by the I-language satisfy "legibility conditions" – a common coin – whereby it can be read by the sensory and motor systems. This requirement would seem to invite the kind of probabilistic model of intentionalistic hypothesis confirmation routinely used by perceptual systems that must detect abstruse (e.g. non-physical) linguistic phenomena, precisely along lines sketched by Chomsky and Halle (1968, pp. 24–25, 294). We leave it as an open question whether there might be other, non-intentionalist strategies that might work as well.[17]

Endnotes

1 We shall we concerned here only with mental representations, not with external representations such as pictures, graphs, or spoken or written words.

2 The (unfortunate) term *intentional* is three ways homophonous: in addition to the philosophical use that will be important in this entry, there's of course the ordinary term *intentional,* meaning, roughly, *deliberate*; and then the related but different term *intensional* (with an "s" rather than a "t"), which is contrasted with *extensional,* i.e. where the *extension* of a term is the set of actual things in the world a term refers to, and the *intension* is the way that extension is specified. The notions are related: all deliberate action is intentional in our sense, and many intentional states are intensional.

3 Propositional attitudes are mental states that are standardly picked out by mental words, such as *belief, expect,* or *see* that can take a sentence complement (e.g. a "that … " clause) as a direct object, and which exhibit many of the features enumerated here.

4 cf. Brentano (1874/1995) and Chisholm (1957) for elaboration.

5 See, e.g. Chomsky (1975b, 1986, and 2000) for the relevant references to these figures' views and Chomsky's rejection of them.

6 Scepticism about the role of intentionality in Chomsky's work may have first been raised by Matthews (1980), to which Chomsky (1980b) made what at least seems to be a somewhat equivocal reply (see Rey 2003b, and Collins 2007, for discussion).

7 The grammar of *represent* can vary: if "*x* is a representation of *y* (as G)," then "*x* represents *y* (as G)" and "*x* represents that *y* is G." All that is crucial here is that the *thing* represented can be real or unreal.

8 Chomsky is perhaps reacting here to certain extreme versions of "content externalism" that have been influential in Anglo-American philosophy since the 1970s, where "representations" are often understood to necessarily involve relations to actual external things (see Evans 1982, Millikan 1998). But, as we hope our discussion of Brentano's conceptions has made clear, such a conception is historically anomalous.

9 Chomsky (2000, pp. 26, 125, 173) and others (e.g. Adger 2019) sometimes seem to presume that the representations are of *neural states* that implement them. But this would appear to conflate the neural states that do the representing with the things they represent. After all, a represented phonological feature isn't itself something that is somehow instantiated in a brain, any more than a rotating cube is. This might make one wonder *just what* a linguistic representation is *of,* if it's neither an acoustic or a neural item. Some (e.g. Katz 1981; Soames 1984) have claimed it is of abstract objects, akin to numbers. But this position fails to account for what speakers at least take themselves to be hearing and producing as utterances in space-time. See Rey (2020:289ff) for other options.

10 Similar thoughts (which were the inspiration for the present ones) seem to us implicit in Chomsky's (1959/64, 1965, p. 58) complaints about Skinner, in Pylsyhyn's (1984, p. 148) admonitions about transduction and in Fodor's (1986) suggestions about why paramecia don't have intentionality. We think the problem of abstruse properties is what is ultimately at issue; see Rey (2020:secs 11.1–11.2) for further discussion.

11 Theorists as different as David Adger (2019) and Michael Devitt (2013) seem not to appreciate this point. Adger claims that all interactions between a grammar and its interfaces could be understood as "transduction"; Devitt, that linguistic perception can be explained merely by SLEs *"having"* various linguistic properties rather than representing them. But how could the mere *having* of a linguistic property explain why someone perceives it as such? Most things – even most things in one's brain – *have* plenty of properties that aren't perceived as such; moreover, linguistic properties being abstruse, an explanation is needed for how neural properties could give rise to linguistic perceptions of them.

12 It's an instance of what Fodor (1998, p. 123ff) called the "doorknob"/doorknob problem: if the concept of doorknob is innate (as he thought it was), why is it that it's "triggered" by doorknobs and not by arbitrary stimuli, such as frogs?

13 Or, of course, *not*, or only partly in the case of difficult or ungrammatical speech. There are presumably thresholds. We'll take this as read throughout.

14 This requires that the hypotheses produce specific kinds of sound representations that are comparable to the auditory input; cf. Palmer (1999, pp. 413–414) on this issue as it arises in vision, and Fodor (1998, p. 136ff) on the possible role of prototypes in solving it.

15 See Rey 1997, Chapter 10, for a review of some of the main approaches, and 2020: Chapter 11, for a modest proposal for at least the case of linguistic perception.

16 Note that the issue here is not that a speaker can *hear,* e.g. a noun as such, as if syntax were consciously perceptible, which is as may be, but that at some level what is perceptible must be *represented as syntactic*.

17 Portions of this entry are derived from Collins (2014) and Rey (2020, chaps 8–11), which the reader should consult for fuller discussion.

References

Adger, D. 2019. Linguistic representation: a note on terminology vs. ontology, available at: https://ling.auf.net/lingbuzz/004616?_s=HJCyU-Jh42SAH2Jo&_k=xxn1bUWy_ex1G4yl

Brentano, F. 1874/1995. Psychology from an Empirical Standpoint, translated by A.C. Rancurello, D.B. Terrell, and L. McAlister. 2nd ed., introduction by Peter Simons. London: Routledge.

Burge, T. 2010. *Origins of Objectivity*. Oxford: Oxford University Press.

Chisholm, R. 1957. *Perceiving: a Philosophical Study*. Ithaca: Cornell University Press.

Chomsky, N. 1955/75. *The Logical Structure of Linguistic Theory*. New York: Plenum Press (the ms. was prepared and circulated in mimeograph in 1955–1956, but was not published until 1975, both by Plenum press and by the Univ of Chicago. Only the latter contains an invaluable index).

Chomsky, N. 1959/64. A Review of B. F. Skinner's Verbal Behavior. Language 35: 26–58. Reprinted in Fodor, J. and Katz, J. (eds.), Readings in the Philosophy of Language, pp. 547–578, Englewood Cliffs, NJ: Prentice Hall.

Chomsky, N. 1965. *Aspects of the Theory of Syntax,* Cambridge: MIT Press.

Chomsky, N. 1968/*2006. Language and Mind,* 3rd ed. Cambridge: Cambridge University Press.

Chomsky, N. 1975a. Introduction to Chomsky (1955/75).

Chomsky, N. 1975b. *Reflections on Language*, New York: Pantheon Books.

Chomsky, N. 1981. *Lectures on Government and Binding*. Dordrecht: Foris.

Chomsky, N. 1980a. *Rules and Representations*. Oxford: Blackwell.

Chomsky, N. 1980b. Précis of *Rules and Representations* with commentaries and replies. *Behavioral and Brain Sciences* 3: 1–61.

Chomsky, N. 1980c. "The New Organology." *Behavioral and Brain Sciences* 3: 42–61.

Chomsky, N. 1986. *Knowledge of Language: Its Nature, Origin and Use*. New York: Praeger.

Chomsky, N. 1995. *The Minimalist Program*. Cambridge: MIT Press.

Chomsky, N. 2000. *New Horizons in the Study of Language*, Cambridge: Cambridge University Press.

Chomsky, N. 2004. *Introduction to Chomsky (1968/2004)*.

Chomsky, N. 2016. *What Kind of Creatures Are We?* New York: Columbia University Press.

Chomsky, N., and Halle, M. 1968. *The Sound Pattern of English*. Cambridge: MIT Press.

Churchland, P. 1979. *Scientific Realism and the Plasticity of Mind* (Cambridge U. P.,

Churchland, P.M. 1981. "Eliminative Materialism and the Propositional Attitudes." *Journal of Philosophy* 78: 67–90.

Collins, J. 2004. A Review of Louise M. Antony and Norbert Hornstein's (eds.) *Chomsky and His Critics*. *Erkenntnis* 60 (1): 27–281.

Collins, J. 2007. *Meta-scientific Eliminativism: A reconsideration of Chomsky's Review of Skinner. In British Journal for the Philosophy of Science* 58: 625–658.

Collins, J. 2014. *Representations without Representa: Content and Illusion in Linguistic Theory*. In Piotr Stalmaszczyk (ed.), *Semantics and Beyond: Philosophical and Linguistic Inquiries*. pp. 27–64. Berlin: De Gruyter.

Devitt, M. (2013a), "Linguistic Intuitions are not the "Voice of Competence," in M. Haug, (ed.), Philosophical Methodology: The Armchair or the Laboratory?, London: Routledge.

Dretske, F. 1981. *Knowledge and the Flow of Information*. Cambridge: MIT Press.

Egan, F. 1992. Individualism, computation and conceptual content. *Mind* 101: 443–459.

Egan, F. 2014. How to think about mental content. *Philosophical Studies* 170: 115–135.

Fodor, J. A. 1986. "Why paramecia don't have mental representations," Midwest Studies in Philosophy, X (1): 3–23

Fodor, J. 1987a. Why paramecia don't have mental representations. *Midwest Studies in Philosophy X* (1): 3–23.

Fodor, J. 1987b. *Psychosemantics*. Cambridge: MIT Press.

Fodor, J. 1990. *A Theory of Content and Other Essays*. Cambridge: MIT Press.

Fodor, J. 1998. *Concepts: Where Cognitive Science Went Wrong*. Cambridge: MIT Press.

Fodor, J., and Pylyshyn, Z. 1981. How direct is visual perception? Some reflections in Gibson's "Ecological Approach." *Cognition* 9: 139–196.

Goodman, N. 1949. On likeness of meaning. *Analysis* 10 (1): 1–7.

Hempel, C. 1962. Deductive-nomological vs. statistical explanation. In Minnesota Studies in the Philosophy of Science vol. III. H. Edited by H. Feigl and G. Maxwell. Minneapolis: University of Minnesota Press, pp. 98–169.

Katz, J. 1981. *Language and Other Abstract Objects*, Totowa, NJ: Rowman and Littlefield.

Lewis, D. 1970. How to define theoretical terms. *Journal of Philosophy* 67: 427–444.

Lidz, J., and Gagliardi, A. 2015. How Nature Meets Nuture: Universal Grammar and Statistical Learning. *Annual Review of Linguistics* 1 (1): 2.1–12.21. http://ling.umd.edu/~jlidz/LidzGagliardiARL2015_preprint.pdf

Matthews, R. 1980. "Language learning vs. language growth," *Behavioral and Brain Sciences*, 3: 2–26.

Matthews, R. 2006. "Knowledge of Language and Linguistic Competence," in E. Sosa and E. Villanueva (eds), *Philosophy of Language: Philosophical Issues* 16, Oxford: Blackwell, pp. 200–20.

Matthews, R. 2010. *The Measure of Mind: Propositional Attitudes and their Attribution* Oxford: Oxford University Press.

Quine, W. 1953/1961. Two dogmas of empiricism. In *From a Logical Point of View, 2nd revised edition*, pp. 20–47. New York: Harper & Row.

Quine, W. 1960/2013. *Word and Object*, 2nd ed. Edited by Dagfinn Føllesdal. Cambridge: MIT Press.

Palmer, S. 1999a. *Vision Science: Protons to Phenomenology*, Cambridge, MA: MIT Press.

Poeppel, D. 2012. The maps problem and the mapping problem: Two challenges for a cognitive neuroscience of speech and language. *Cognitive Neuropsychology* 29 (1–2): 34–55.

Pylyshyn, Z. 1984. Computation and Cognition: Towards a Foundation for Cognitive Science, Cambridge, MA: MIT Press.

Recanati, F. 2012. *Mental Files*. Oxford: Oxford University Press.

Rey, G. 1997. *Contemporary Philosophy of Mind: A Contentiously Classical Approach*. Oxford: Blackwell.

Rey, G. 2003a. Chomsky, intentionality and a CRTT. In *Antony, L. and Hornstein, N., Chomsky and His Critics*, pp. 105–139. Oxford: Blackwell.

Rey, G. 2003b. Representational content and a Chomskyan Linguistics. *Epistemology of Language*, edited by A. Barber, pp. 140–186. Oxford: Oxford University Press.

Rey, G. 2008. *In Defense of Folieism. Croatian Journal of Philosophy*.

Rey, G. (2020), *Representation of Language: Philosophical Issues in a Chomskyan Linguistics. Oxford: Oxford University Press.*

Soames, S. 1984. Linguistics and psychology. *Linguistics and Philosophy*, 7: 155–179.

32

The Mind–Body Relation: Problem, Mystery, or What?

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In this chapter I want to respond to Chomsky's claim, repeated often in different ways, that "[there is no] reason for qualms about an 'explanatory gap' between the physical and consciousness … " (Chomsky 2016, p. 87), largely because we have no clear conception of "body" or "the physical." As someone whose entire career has largely been spent making the case that there is such an explanatory gap, his critique clearly hits close to home. I will argue both that Chomsky's own position suffers from inconsistency – he dismisses the apparent problem while at the same time promoting it as a "mystery" – and that his principal reason for maintaining his position, that there is no clear conception of body, or the physical, with which to contrast the mind, or the mental, doesn't really dispense with the issue that rightfully worries philosophers. Let me make clear from the outset that my beef is with these philosophical views on the mind–body problem alone; I do not take my arguments to in any way conflict with Chomsky's general views of the nature of mind and language. In fact, to the extent that Chomsky sometimes presents his philosophical views as a defense against philosophical objections to his approach to cognitive science and linguistic theory, I side with Chomsky. I don't see any tension in accepting his theory of language and mind and, at the same time, in acknowledging the existence of a mind–body problem.

How to understand the relation between the mental and the physical – or, mind and body – has been the central question animating philosophy of mind for centuries. Descartes famously argued, both on empirical and more purely philosophical grounds, that the mind must be a distinct kind of substance from the body, because body, or matter, is not capable of sustaining thought and conscious experience. He posited two basic kinds of substance: matter, the essential property of which is extension, and mind, the essential property of which is thought (which, in his mind, included consciousness).[1] Of course, since it's evident that mental and physical phenomena causally interact – as when my speech intentions get my mouth and tongue to move, and when light hitting my retina gets me to have a visual experience – Descartes immediately faced the problem of explaining how two such different substances, one

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of them extended in space and the other not, could possibly interact in this way. Most would agree that Descartes never adequately addressed the problem, and it plagues dualists to this day.

From the mid-twentieth century on, the issue was usually framed in terms of the doctrine of "physicalism" (or "materialism" – I will use the two terms interchangeably). Stating physicalism precisely is, as is precisely stating any doctrine in philosophy, a somewhat controversial matter. But basically, the idea is that all concrete phenomena are reducible to, or realized in, or grounded in physical phenomena. At the very least, physicalism seems committed to a metaphysical supervenience thesis; as Quine put it, "no difference without a physical difference" (Hylton 2007, p. 316). Or, put another way, if you fix all the physical facts, you've fixed all the facts period.

The generalization of physicalism from mental phenomena to all phenomena (or all spatio-temporally located phenomena) followed from the same idea: basic, or fundamental physical mechanisms are presumed to provide all the features responsible for causal interactions within our world, so any phenomenon that plays any causal role must be reducible to the physical. Therefore, much of the debate in philosophy of mind became subsumed in the general debate over the broader thesis of physicalism in general.

Near the end of the last century, the thesis of physicalism came under pressure from philosophers who questioned its meaningfulness because of an alleged lack of clarity over the very notion of the physical.[2] A very popular way to put the problem was to revive an earlier challenge due to Hempel (1980) that was called, appropriately enough, "Hempel's dilemma." What do we mean by "physical" anyway? One horn of the dilemma is to pin the meaning of "physical" on current physical theory. By "physical," we just mean the stuff studied in Physics departments. The problem with this option is that the discipline of physics is always changing, so entities and properties not currently posited by physical theory – and hence not "physical" according to this "currentist" definition[3] – will be included in the future, and hence ought to count as physical. The other horn of the dilemma is to appeal to some idealized future physics, and deem physical anything posited in this ideal theory. But now the problem is that we don't know what this theory will include, and so don't have a clear idea what we are reducing mental and other phenomena to when we allegedly reduce them to the physical. Either way, it seems physicalism is a doctrine that can't be meaningfully stated.

Chomsky has presented this critique of physicalism very forcefully. To the general worry about how to define "physical" expressed in Hempel's dilemma above, he has added a particular concern about our grasp of the notion of body that derives from what he characterizes as Newton's destruction of the earlier "mechanical philosophy." After arguing that Newton's theory of gravity, which involves action at a distance, destroyed the basis of the "mechanical philosophy," he says:

> the [traditional mind-body] discussions presuppose some antecedent understanding of what is physical or material.... These terms had some sense within the mechanical philosophy, but what do they mean in a world based on Newton's "mysterious force," or still more mysterious notions of fields of force, curved space, infinite one-dimensional strings in ten-dimensional space, or whatever science concocts tomorrow? Lacking a concept of "matter" or "body" or "the physical," we have no coherent way to formulate issues related to the "mind-body problem." (Chomsky 1995, pp. 4–5)

From this quote, it is clear that Chomsky believes that the "mind–body problem," as traditionally understood, is not a real problem at all. When we had a clear notion of

body, or matter, that involved the "contact mechanics" of pre-Newtonian theory, then we could wonder how it is that such an entity could support mental properties. But once we've lost this clear idea of what the material is, the question of how it can support the mental becomes meaningless. What is this "it" for which one needs an answer as to how it can support mentality? This really is quite a radical thesis. Chomsky expands on this view by quoting Joseph Priestly approvingly regarding the relation between mind and body:

> In Priestley's words, matter "is possessed of powers of attraction and repulsion" that act at a "real and in general an assignable distance from what we call the body itself," properties that are "absolutely essential to [the] very nature" of matter … With the Newtonian discoveries, matter "ought to rise in our esteem, as making a nearer approach to the nature of spiritual and immaterial beings," the "odium [of] solidity, inertness, or sluggishness" having been removed. Matter is no more "incompatible with sensation and thought" than with attraction and repulsion. "The powers of sensation or perception and thought" are properties of "a certain organized system of matter"; properties "termed mental" are "the result (whether necessary or not) of such an organical structure as that of the brain [just as] sound is the necessary result of a particular concussion of the air." Thought in humans "is a property of the nervous system, or rather of the brain." (Chomsky 1995, p. 8)

One might wonder how matter can "rise in our esteem" at the same time we can have "no conception of it," but I take it Chomsky means something like this. We have an (innate – we'll get to that) conception of matter that constitutes our commonsense notion, and this was the basis for the notion of matter underlying the mechanical philosophy. Essential to it is the idea that bodies can only affect each other through contact. Action at a distance is completely foreign to this notion of matter; indeed, hardly intelligible to commonsense understanding, in the same way that, say, multidimensional space is impossible to imagine. Newton's theory of gravity then completely undermined this commonsense notion of matter. Still, there are all those things out there we call "material," and describe as "bodies"; they haven't disappeared. When Chomsky is saying, in Priestley's words, that matter is possessed of this or that feature, he here doesn't mean the official "contact mechanics" notion of body, but just whatever it is that constitutes these things around us we call "bodies."

The main point Chomsky takes away from Priestley in the quoted passage, then, is this. When we consider our physical bodies and organs, including the brain, we shouldn't conceive of these entities as satisfying our commonsense notion of what a material body is. It turns out, after Newton, nothing satisfies that conception. But it was only in connection with that commonsense notion of body that there was any problem about how it could sustain mentality – thought and consciousness. So now, with our new Newtonian conception of matter, one that allows it to have occult features like acting at a distance, there shouldn't be any conflict with attributing mental features to it. Matter is just whatever is out there, and it has whatever features it needs to have to explain its behavior, whether they be "physical" or "mental."

This last point connects with another important piece of Chomsky's philosophy of science: his "naturalism." For Chomsky, naturalism is a methodological doctrine, not a metaphysical one. It consists in just confronting the phenomena we find in the world and, based on that, constructing theories to explain it. As he puts it:

> A naturalistic approach to linguistic and mental aspects of the world seeks to construct intelligible explanatory theories, taking as "real" what we are led to posit in this quest,

> and hoping for eventual unification with the "core" natural sciences: unification, not necessarily reduction. Large-scale reduction is rare in the history of the sciences. Commonly the more "fundamental" science has had to undergo radical revision for unification to proceed. (Chomsky 1995, p. 1)

Now I think Chomsky is making two points here, one of which seems eminently reasonable and the other one, the one pertinent to our discussion, is much more controversial. The former is just the claim that whatever posits we need to explain natural phenomena have earned their ontological keep by their explanatory roles. Thus, if we need to posit innate computational structures to explain the facts of language acquisition – and other mental phenomena – then we have reason to believe in them. The mere fact that we can't yet figure out how our computational characterization of the brain, say, coheres with a neuroscientific one, doesn't give us reason to abandon the computational one. Throughout the article just cited, Chomsky expresses the frustration that standards for taking the sciences of the mind seriously, realistically, are often taken by philosophers to be different, more stringent, than those for other sciences. If this is what his naturalism comes to – a plea for the explanatory worth of psychological and linguistic theories – then I see nothing to disagree with.

However, I think Chomsky is making another point here. By contrasting "unification" with "reduction," he seems to be saying that it is part of a naturalistic framework to treat all theories on a par – every theory targets some domain of phenomena, at first only vaguely marked out, and then attempts to construct an explanatory theory for that domain. Each aspect of the world is on a par with every other aspect, so when it comes to integrating theories the main goal is "unification," not "reduction." While reduction seems to accord a more fundamental role to the reducing theory, unification treats neither theory as more basic, or fundamental than the other. While I certainly believe we can proceed to construct, and take ontologically seriously, explanatory theories in psychology and linguistics without necessarily bothering to figure out how they fit with physics or neuroscience, that doesn't mean that some domains are not, ontologically, more fundamental than others. We shouldn't throw out a good explanatory theory of language acquisition just because we can't (yet?) figure out how the relevant structures are implemented in the neurology – even if we never do – but that doesn't mean the lack of unification – indeed reduction – isn't a problem; perhaps even a "mystery."

This brings us to the apparent inconsistency in Chomsky's position mentioned at the beginning of the paper. On the one hand, as we've seen, Chomsky argues that we currently have no scientifically respectable notion of matter on which it should seem problematic to attribute mental features to it. On the other hand, he has also said that explaining how it is that biological organisms such as ourselves can support mentality – in particular, what he calls the "creative aspect of language use" – might constitute a genuine "mystery." As the term *mystery* is a technical term for Chomsky, let me explain what he means by that before elaborating on the alleged inconsistency in his position.

Just as with language, Chomsky argues that underlying other cognitive abilities – in particular, our "science-forming" ability – are innately and richly structured cognitive systems. It is the rich innate structure of these systems that allows them to develop such complex behavior in response to very limited and chaotic data provided by the environment. However, just as rich innate structures provide the tools to accomplish amazing cognitive feats (such as acquiring a language and developing sophisticated scientific

theories), they do so by severely restricting the hypothesis space, indeed the conceptual space, within which these systems operate. Being innately finely tuned to solving some problems (such as acquiring the grammar underlying the linguistic data available to the child) entails being excluded from entertaining, or in some cases even formulating, the hypotheses and theories that would solve others. Thus, Chomsky distinguishes between what he calls "problems" and "mysteries": Problems are what we have the innate capacity to solve, while mysteries are those questions our innate endowment doesn't provide us the conceptual tools to answer. As he puts it:

> As for the matter of cognitive reach, if humans are part of the natural world, not supernatural beings, then human intelligence has its scope and limits, determined by initial design. We can thus anticipate that certain questions will not fall within their cognitive reach, just as rats are unable to run mazes with numerical properties, lacking the appropriate concepts. Such questions we might call "mysteries-for-humans," just as some questions pose mysteries-for-rats. Among these mysteries may be questions we raise, and others we do not know how to formulate properly or at all. (Chomsky 1995, p. 2)

From what we've seen so far, according to Chomsky there shouldn't even really be a "problem" about the mind–body relation, except for the issue of unification, which he doesn't seem to think is a very pressing problem. However, in other passages, Chomsky seems to say that how the body, or brain, supports mental life might very well constitute a genuine mystery. Here are a couple of illustrative passages:

> … how can organized matter have these properties? Well on that question, progress has been essentially zero. We don't know anything, we have nothing to say about how organized matter can have such properties as the creative aspect of language use, in that respect we're exactly as much in the dark as the Cartesians were. (Chomsky 2016a)

> [These issues] still seem to pose a complete mystery. They are, for example, unaffected by the transition from the complex artifacts that intrigued the Cartesians to today's computers, and the brain sciences shed little light on them. (Chomsky 1995, p. 27)

It certainly seems like he's saying in these passages that how it is that "organized matter" – "today's computers" or the brain – can possess mental features is a mystery; or it might very well be one. (You can never tell for certain which questions are beyond our "cognitive reach.") If, as he approvingly quoted Priestley above, matter is no more "incompatible with sensation and thought" than with attraction and repulsion, then what is supposed to be the mystery we still face today in understanding how the brain supports mentality?

I have two hypotheses about what's going on here that might relieve the tension between these two apparently conflicting arguments. I present them speculatively, as I really don't know if they capture his position accurately. First, it might be that when it comes to what he calls "the creative aspect of language use" there is a special problem, one that outstrips general mind–body worries. As he puts it:

> … language is unbounded, stimulus free, not determined by internal state, even though heavily influenced by it. Appropriate to situations but not caused by situations, in fact apparently uncaused … That collection of properties, call it the creative aspect of language use is, Descartes argued, … a test for some other aspect of the world, for some property of the world that does not fall within mechanism. (Chomsky 2016a)

The problem that seems to have Chomsky worried is essentially the free will problem. How is it that subjects can execute courses of action that are "appropriate" to the circumstances and yet undetermined? In particular, how can this ability be present in organisms whose motions seem to be law-governed at least up to randomness, a kind of indeterminacy that does not explain intelligent action, including the choice of what to say in a given situation? So, one interpretation of his position is that when it comes to consciousness and intentionality, we know nothing of matter that should preclude its possession of these features, and so there is no serious problem or mystery here. However, when it comes to the creative aspect of language use there is a mystery because of this combination of appropriateness and indeterminacy.

I don't know if distinguishing the free will problem from the traditional mind–body problem in this way – making the former a genuine mystery and the latter literally meaningless, and so not even a problem – does capture what Chomsky has in mind. But if it is his view, I wonder if he isn't conflating two distinct issues here about the limits of scientific theorizing. On the one hand, appealing to the notion of cognitive limitations, it certainly seems possible that there are domains for which we just aren't cognitively equipped to formulate the appropriate theories. These would be domains that pose genuine mysteries in Chomsky's sense.

On the other hand, some domains are not apt for theorizing because the phenomena they contain, though appearing unified to common sense, are actually the results of massive interaction effects among disparate systems answering to their own laws and principles. While linguistic theory might explain both how we acquire complex grammars from poverty-stricken data and how we have the resources to generate an unbounded list of sentences, it might have nothing to say about why we choose to say this particular sentence at this particular time. For that we'd need to appeal also to many other systems that together result in the particular speech behavior performed. There not being a theory of speech behavior may therefore be better explained by the hypothesis that speech behavior, or all intelligent action, does not constitute a proper theoretical domain in itself than by its having mysterious provenance. It could be a mystery, but for now I don't see sufficient reason to rule out the second explanation, appealing to speech behavior – indeed all behavior – as just a massive interaction effect.

Perhaps Chomsky is making this distinction; but somehow I don't think that's the entire story. There is another possible interpretation of Chomsky's position that might relieve the tension between his two views of the mind–body problem. At one point he says that the Cartesian arguments against a materialist theory of thought, or intentionality, " … can be reconstructed, *though now without metaphysical implications,* since the concept of matter has disappeared" (Chomsky 1995, p. 27, my emphasis). So maybe this is what he has in mind. Before Newton, when we were working with an intelligible conception of body as captured by the "mechanical philosophy," it seemed downright impossible, inconceivable, for bodies of that kind to manifest mentality. It wasn't just a matter of ignorance how a material thing could support thought, but, to paraphrase Priestley, on the old conception, matter was "incompatible with sensation and thought." However, once Newton undermined the conception of matter definitive of the mechanical philosophy, any reason for finding an incompatibility between mind and matter disappeared. Nevertheless, a "unification" question remained; namely, how do the theoretical descriptions of systems from psychology and linguistics mesh with the theoretical descriptions of those same entities from physics, chemistry, and biology? This issue remains, even if the "metaphysical" problem has vanished. On this question

Chomsky is quite pessimistic of our making progress and seems to believe it may really constitute a mystery. But the real philosophical problem is gone, since that depended on there being a substantive incompatibility between our notions of mind and matter, and since we have no clear notion of matter anymore there can't be an incompatibility of that sort.

Some support for this interpretation can be found in a comment by Chomsky on a famous remark of Jerry Fodor's. Fodor said:

> I suppose that sooner or later the physicists will complete the catalogue they've been compiling of the ultimate and irreducible properties of things. When they do, the likes of spin, charm, and charge will perhaps appear on their list. But aboutness surely won't; intentionality simply doesn't go that deep. (Fodor 1987, 97)

Chomsky comments:

> *It may seem offensive to common sense and sound thinking* to suppose that certain matters (intentionality and aboutness, consciousness, behavior that is uncaused but appropriate, or whatever)[4] are among the "ultimate and irreducible properties of things" that physicists seek to catalogue. But the stipulation is not very helpful. Why these but not attraction and repulsion? (Chomsky 1996, p. 44, my emphasis)

From the italics phrase it seems that Chomsky interprets Fodor to be claiming that there is something like a conceptual barrier to attributing intentionality (or other mental properties) directly, or "irreducibly" (more on this in a moment) to matter. This is why he thinks once we are willing to attribute action at a distance, after Newton, we should also be prepared to attribute aboutness; what's the difference? As I said, this latter interpretation is speculative on my part and I don't know if it accurately captures Chomsky's intent. In the end, though, whether or not it does, I disagree with Chomsky's basic claim that after the demise of the mechanical conception of body in the face of Newtonian – and then later – physical theory, no meaningful puzzle about how the mental relates to the physical can be posed. To see why, let me lay out my conception of the mind–body problem, and explain why I think it is still a serious and pressing challenge.

To begin with, though I've alluded to the distinction already, and it comes up in the Fodor quote, let me explain what I take the distinction between basic (or fundamental, I use the terms interchangeably) and nonbasic properties (and laws) to be. For present purposes let's restrict our discussion to phenomena that play a causal role; that is, events that have causes and cause other events. When we investigate a domain – whether it be planetary motion, digestion in mammals, or thought processes – we are largely concerned with mapping the causal relations among the various events constituting that domain, and uncovering the properties responsible for the various causal interactions. When Chomsky, as quoted earlier, says we look for explanatory theories of the domain, I take it that a large part of what it is to explain a phenomenon is to elucidate why it occurred, which means articulating the kinds of properties causally responsible for the behavior we see.

Now, when it comes to causal mechanisms, a natural division among them is between those that are basic and those that are not. A nonbasic, or realized, mechanism is one that results from the activity of other mechanisms – not as a causal result, but rather, as a constitutive result. The best example is the one functionalists in philosophy of mind

trade on – the relation between computer programs and the electrical mechanisms that implement them. When my computer goes through the various electrical states that it does when retrieving a file, these state changes don't *cause* the file to be retrieved, but rather *constitute* its being retrieved. Given this relation, we can say that the action of file retrieval is *realized* in the relevant electrical state changes, and this makes it a nonbasic event. Basic events and properties are just those causal transactions (and the properties involved in them) that are not realized in, or constituted by, other events and properties. This is what makes them fundamental. Natural scientists are, as far as I can tell, partly in the business of discovering the basic mechanisms of our world, and how they relate to other, nonbasic mechanisms.

Looked at through the lens of the basic/nonbasic distinction, the thesis of "physicalism" is the thesis that there exists one connected system of basic properties and mechanisms that both correspond in some crucial way to the discipline of physics and provide foundation for all other properties and mechanisms. I agree with Chomsky that to meaningfully state this thesis, one has to elucidate what it is that unites all of these basic properties under the heading "physical," and there are serious challenges to providing such an account. In fact, it seems to me that whether the world's basic entities and properties form a natural category that corresponds to our prior notion of the physical or to the domain of the discipline of physics, it is a straightforward, empirical question and not really a philosophical one. If there are "emergent" chemical, or even biological phenomena, then so be it. It turns out, if this be the case, that the world is less tidy than we thought.

But this issue – whether there is a coherent base that can rightfully be called "physical" – is not what the mind–body problem is about. Rather, in my view, the right way to construe the mind–body problem is to ask the following question: Are mental phenomena basic, or fundamental, or are mental phenomena realized in, or reducible to, nonmental phenomena? The relevant contrast is not mind and body, or the mental and the physical, but rather, mind and not mind, the mental and the nonmental. This is what was exercising Fodor in the quote above. Is intentionality (the mental feature he was there concerned with) a basic feature of the world or not? I see nothing in the Newtonian and post-Newtonian demolition of our commonsense conception of the physical that undermines the legitimacy of that question.

A good analogy for the mind–body problem is the "naturalization" debate in meta-ethics; indeed, *naturalization* is a term that occurs often in the context of both debates. In meta-ethics, the question is this: Can the normative be reduced to the non-normative – the descriptive – or not? Again, though some might fold the meta-ethical dispute into the general debate over physicalism, it seems to me that meta-ethics is concerned with a very specific question that is independent of any issue about the reducibility of chemistry or biology to physics: namely, are normative properties – the right and the good – basic, or are they realized in non-normative properties, whatever these turn out to be? In the context of ethics, *natural* means non-normative; in the context of philosophy of mind, *natural* means non-mental (and, I would argue, in particular non-intentional).[5]

One might challenge my take on the mind–body problem by questioning whether we have a clear sense of the "mental" any more than we do of the "physical." But unlike the case of the physical, with its action at a distance, electromagnetic fields, and quantum indeterminacy, I don't see any reason for doubting that we have a meaningful conception of the mental, a conception sufficiently clear to make sense of the question whether

it is basic or not. Again, there seem to be two fundamental ideas associated with our commonsense conception of the mental: intentionality, or "aboutness," and consciousness. Fodor's "naturalization" project in the work cited above was to show that "aboutness" is not basic and can be realized by nonintentional properties and mechanisms. Whether he's right is, of course, controversial. But it doesn't seem controversial to me that the question is a sensible one.

As mentioned above, Chomsky's emphasis on "unification," as opposed to "reduction," could be seen as a rejection of this metaphysical division I'm drawing between the basic and the nonbasic. It's hard to tell. But I can't myself see any problem or incoherence in drawing the distinction. As I admitted earlier, it might be that nature is not so well-behaved that there is a single set of basic properties that serve as the underlying causal mechanisms for everything else in nature. After all, Aristotle might have been right in theorizing that the principles of motion that govern objects in the terrestrial domain are quite different from those that govern the motion of celestial objects. But that possibility doesn't undermine the distinction between the basic and the nonbasic. If Aristotle were right, then there would be certain terrestrial features that are basic for motion on Earth and others that are basic for motion in the heavens. We could still ask of yet other earthly or heavenly phenomena whether they were realized in these basic properties or are yet further basic properties of these two disparate domains.

Having made my case both that there is a sensible mind–body question to be asked and that the distinction between basic causal mechanisms and nonbasic ones, on which the mind–body question is based, is also sensible, I want to say something about why this question seems so pressing, and why so many philosophers have thought that a reduction of the mental to the nonmental must be possible. Contrast the mind–body issue with Aristotle's issue about the mechanisms underlying terrestrial and celestial motion. While we now know that Aristotle was wrong and that the spatial domains of the celestial and the terrestrial are unified and governed by the same principles, from his point of view it didn't seem at all outlandish to think these two spaces might have constituted distinct domains.

However, the same cannot be said of the mind and the body. The problem is the causal interaction issue mentioned earlier, and a related, causal overdetermination problem. Thoughts and experiences are evidently caused by and cause motion and changes in other "physical" magnitudes, such as electromagnetic fields. Our best explanatory theories of these motions and other changes in physical parameters do not appeal to mental features like aboutness and experience to explain them.[6] So if behavior, bodily motion that is apparently caused by thought and experience, is really caused by these mental features, how do they relate to the clearly nonmental features discussed by physicists and chemists that seem to account for the bodily motions in question? If, as materialist philosophers believe, the mental is realized in the nonmental, then an intelligible answer to this question exists. But many anti-materialist philosophers – including myself (Levine 2001) – have challenged the intelligibility of philosophical theories that purport to reduce the mental to the nonmental. I don't want to rehearse those arguments here, but just want to make the point that there is a real problem and a substantive matter on which a substantive dispute exists.

As mentioned above, Chomsky explicitly disparages the claim that the mental–physical relation poses an "explanatory gap." Comparing that case to the physical-chemical case, he writes:

> Adopting contemporary terminology, we might say that Dalton disregarded the explanatory gap between chemistry and physics by ignoring the underlying physics, much as post-Newtonian physicists disregarded the explanatory gap between Newtonian dynamics and the mechanical philosophy by ignoring (and in this case rejecting) the latter, though it was self-evident to commonsense understanding. (Chomsky 2016b, pp. 107–108)

His point seems to be that just like Dalton's theories were able to perform their explanatory function without any concern about the underlying physics, so too should we not worry about the mental relation to the underlying physical mechanisms. While there is something clearly right about this – as I've already granted above – I don't think the two cases are completely analogous.

What seems right is this. If we have a psychology that is successfully explaining and predicting human behavior and capacities, we don't throw it out, or downgrade its ontological status, just because we can't yet figure out how it "unifies" with other theories. I do not think the philosophical mind–body problem should function as a drag on psychological and linguistic theorizing. However, the mental–physical case is different from the chemical–physical case in an important way. As I understand it, the issue that chemists faced was that relatively macro phenomena, such as chemical bonding to forge molecules, didn't have an explanation in terms of the features of the elementary parts out of which the molecules were constructed. So, there was a question whether truly emergent properties and laws were needed to fill this gap. If so, then chemical properties and mechanisms might turn out to be basic.

So, in the chemical–physical case, unlike the mind–body case, the problem was not that we had two explanatory theories of molecule formation, with distinct theoretical taxonomies, one in terms of the properties and laws governing elementary particles and also another one at the chemical level, and we couldn't see how they cohered with each other. Rather, there was a real gap at the elementary level when it came to the explanation of bonding; there was no theory that explained it in terms of elementary physics. But so far our best theories of state changes in the brain seem to tell us that nonmental properties (physical–chemical ones) are completely responsible for them (even though we aren't yet in a position to chart their complete course in detail). Given that it is these state changes in the brain that are causally responsible for the very same behavior to which we attribute mental causes, the relation between these two types of causes – the ones describable in nonmental terms and the ones describable in mental terms – seems very pressing indeed.

At this point, Chomsky might trot out the response mentioned above, that I don't really have a sufficiently clear conception of the mental on which to base the mind–body problem after all. I have in mind some disparaging remarks he makes about the very notion of intentionality. Typical of such remarks is the following:

> … leading to extensive and it seems pointless debate over such alleged questions as whether machines can think … It is not a question of fact, but a matter of decision as to whether to adopt a certain metaphorical usage, as when we say (in English) that airplanes fly but comets do not-and as for space shuttles, choices differ. Similarly, submarines set sail but do not swim. There can be no sensible debate about such topics; or about machine intelligence, with the many familiar variants. (Chomsky 1995, p. 9)

What I take from this is the idea that we shouldn't take intentional terminology too seriously, and that intentional properties are not real, or ontologically serious;

using them is just a way we choose to talk, and therefore it's not a substantive question whether or not they should be applied to brain states or computer states. If so, asking whether or not intentionality is basic in nature is not a very interesting question, with no metaphysical implications. (Of course, that still leaves the issue of phenomenal properties, but maybe he'd say the same thing there. I'm not clear what his view of the phenomenal is, or whether he even has one.)

I have two replies to this objection: First, it does seem that a whole lot of explanation in cognitive science – from the psycho-physics of perception, theories of attention, developmental theories of core cognition and conceptual development, to theories of rational decision-making – are shot through with intentional vocabulary. Second, I would also just stand my ground and claim that I do know what I have in mind by "intentional," or at least "aboutness," and it isn't merely a matter of how I choose to talk or a decision about how to use a certain term. I have actual conscious experiences and actual thoughts that are about things. These truths seem evident to me, and therefore a reasonable question arises: Do these features of my experience – with which I'm intimately acquainted – reduce to nonmental features of my body or not? There are good arguments on both sides of this question, which is why it is still considered a serious problem in philosophy of mind. In fact, let me end by quoting from Chomsky himself, in a passage in which he was speaking of Descartes's appeal to the creative aspect of language use. He said:

> Now we could be completely wrong about this, maybe we're being misled about the facts, but these facts as the Cartesians argued, seem as obvious to us as anything could be on immediate inspection *and as Descartes again argued, it would be absurd to deny that which appears obvious to us, simply on the grounds that we may not have intelligence enough, or at least we do not now, have intelligence enough to understand it. That would simply be irrational and he therefore argued and I think we're still in this situation, that we have to take these things very seriously*. (Chomsky 2016a, my emphasis)

Well, I will say the same thing about aboutness and phenomenal experience. I think it would be irrational to deny that these properties exist, and even if we can't figure out how they could be realized in the unintentional and the non-phenomenal, that's no reason to deny the obvious. Maybe, as Chomsky says concerning at least some mental attributes, it will always remain a mystery how the organized matter of our brains can support these features. But maybe not. I don't see why we shouldn't push to clarify the issue and seek solutions – that is, do philosophy. If it really is beyond our cognitive capacity, then we won't succeed. But why give up now?

Endnotes

1 These days, since the work of Brentano, "thought" is taken to include what is called "intentionality," or the property by virtue of which thoughts are "about" things, whether objects or properties. "Intentionality" is used by philosophers in this quite general way, and is not confined to its ordinary use as a way of qualifying actions, as in "she did it intentionally."

2 See Montero (1999) for a sharp presentation of the problem.

3 A defender of the "currentist" approach is Melnyk (1997). For a thorough examination and defense of the thesis of physicalism, see Melnyk (2003), and also Poland (1994).

4 This passage seems to contradict my first attempt at relieving the tension in Chomsky's position, as he seems to lump all mental properties in together. But it does seem that when he talks

about there being a mystery, it's usually connected with what he calls "the creative aspect of language use."

5 See Levine (2016, 2018) for discussions of naturalism in the contexts of both philosophy of mind and meta-ethics.

6 This was Fodor's point; not that it would be an offense against common sense to attribute basic intentionality to the physical, but that it just doesn't seem to be the way that physical theory is going. When not dealing explicitly with macro-mental phenomena, the claim is that natural scientists do not appeal to intentional states of physical systems to explain their behavior. If they did in general, then we'd be in an entirely different ballgame.

References

Chomsky, N. 1995. Language and nature. *Mind* 104 (413): 1–61.

Chomsky, N. 1996. *Powers and Prospects: Reflections on Human Nature and the Social Order*. Boston, MA: South End Press.

Chomsky, N. 2016a. *Chomsky on the Cognitive Revolution*. Transcript of interview, https://bertrandchomsky.wordpress.com/2016/12/05/first-blog-post/

Chomsky, N. 2016b. *What Kind of Creatures Are We?* New York: Columbia University Press.

Fodor, J. A. 1987. *Psychosemantics: The Problem of Meaning in the Philosophy of Mind*. Cambridge: MIT Press.

Hempel, C. 1980. Comments on Goodman's *Ways of Worldmaking*. *Synthese* 45: 193–199.

Hylton, P. 2007. *Quine*. London: Routledge.

Levine, J. 2001. *Purple Haze*. Oxford: Oxford University Press.

Levine, J. 2016. Naturalism and dualism. In *The Blackwell Companion to Naturalism, edited by Kelly Clark*, 209–219. Malden, MA: Wiley-Blackwell.

Levine, J. 2018. Bruteness and supervenience: Mind vs. morality. In *Brute Facts*, edited by Mekios, C., and E. Vintiadis, 45–62. Oxford: Oxford University Press.

Melnyk, A. 1997. How to keep the 'physical' in physicalism. *Journal of Philosophy* 94 (12): 622–637.

Melnyk, A. 2003. *A Physicalist Manifesto*. Cambridge, UK: Cambridge University Press.

Montero, B. 1999. The body problem. *Nous* 33: 183–200.

Poland, J. 1994. *Physicalism: The Philosophical Foundations*. Oxford: Clarendon Press.

Part VII

Methodological and Other Explanatory Issues

33

Chomsky's "Galilean" Explanatory Style[1]

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33.1 Introduction

Chomsky pursues a methodology in linguistics that abstracts from substantial amounts of data about actual language use in a way that has met considerable resistance from many other linguists. He thinks of this method as similar to that employed by Galileo and later physicists who proposed laws of motion in considerable abstraction from many of the motions we observe in daily life, focusing, for example, not on leaves in the wind, but on frictionless environments that virtually never occur on earth. Thus, Chomsky's theoretical proposals are supported not by studies of the corpora of actual language use, but often by the intuitions of native speakers; and the relevant intuitions are not about what they think is *often* or is *likely* to be said, but rather about what *can't* be said (so-called "negative data"), and about what types of interpretation a sentence can or cannot have. But doesn't this fly in the face of good, commonsensical scientific methodology? Aren't theories confirmed by greater data, and refuted by data that seem to conflict with them? With regard to this issue, Chomsky (1980) writes:

> Substantial coverage of data is not a particularly significant result, it can be attained in many ways, and the result is not very informative as to the correctness of the principles employed. It will be more significant if we show that certain far-reaching principles interact to provide an explanation for crucial facts – the crucial nature of these facts deriving from their relation to proposed explanatory theories. (Chomsky 1980, p. 2)

We'll argue below that Chomsky's observation here in fact accords with good explanatory practice elsewhere in science, but it does conflict with a traditional methodology in linguistics. In the spirit of the positivism/empiricism of the 1930s, the structuralist linguist Leonard Bloomfield (1933, p. 20) insisted that "the only useful generalizations about language are inductive generalizations", and linguists for the next several decades tried to specify discovery procedures, or rules for using a collection of phonetically characterized utterances to induce phonemic, morphemic and – it was hoped – finally syntactic analyses of the target language (see Sampson 1980,

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p. 76ff). Such discovery procedures have fallen by the wayside, but many contemporary linguists would still agree with Bloomfield that linguistics seeks generalizations that both emerge from, and provide good coverage of the data of language use.[2]

Those who have made such arguments tend to regard Chomsky's Galilean style as manifestly, even outrageously, unscientific. Chater et al. (2015) claim it "allows a serious researcher to ignore data which is incompatible with his theory":

> There is a very troubling and disturbing problem we encounter as soon as we undertake to ignore data – does it need to be spelled out? The problem with this methodology is this: that each of us … is, perhaps, confident to identify true conjectures which do not appear to be supported by the data, but we are not always so confident about the next person's. And who knows? Someone else might feel exactly the same way about it, only in reverse. *That's* the problem. (Chater et al. 2015, p. 95 – their italics)

Indeed, "there is no philosophy of science that allows one to ignore data" (Chater et al. 2015, p. 96). Similarly, Knight (2016, p. 171) claims that "[w]hen the facts contradict a theory, most scientists would agree that the theory needs to go. But not Chomsky." And Seuren (2004, p. 29) claims that Chomsky, following the Galilean style, is "free to ignore any kind of contrary or refractory evidence to uphold his theory […] One wonders what would become of science if everyone took similar liberties."

In our view, such criticisms are founded on misunderstanding – not so much of Chomsky's position, although there is a good deal of that – as of good scientific method. It's striking that the main features of Chomsky's Galilean style are independently taken to be rather obvious features of scientific method in contemporary philosophy of science. It shouldn't be surprising, for example, that generative syntacticians make use of data that are only collected as a result of the theory under consideration: the same is true of other sciences – from the particle accelerators which allow physicists to produce interactions to order, to the artificial stimuli and controlled conditions of experiments in cognitive psychology.[3] And generativists, like other scientists, are interested in data that bear on their theoretical claims. So quite rationally, scientists discount observations that do not bear on the system under investigation because they hypothesize that they are likely caused by other systems.

In what follows we first look in more detail at the roles that idealization plays in contemporary generative grammar (Section 33.2), and then proceed to explore the congruence between the Galilean style in linguistics and aspects of good scientific methodology (Section 33.3). Finally, we set out and respond briefly to some of the arguments that have been raised against the Galilean style (Section 33.4).

33.2 Idealization in the Sciences

There are several claims at the heart of Chomsky's Galilean style.[4] These include (i) the conception of science as a quest for underlying explanatory structure; (ii) the distinction between superficial generalizations and deeper explanatory principles; and (iii), the claim that the crucial relationship between data and theory is that whatever data is cited should support inferences about the phenomena under investigation, and that any hypotheses about other, interfering causes are correct (see Pietroski and Rey 1995 for how this is a substantive commitment), not that the theory should cover *all* the data in a domain.

33.2.1 Science as Quest for Underlying Structure

> The great successes of the modern natural sciences can be attributed to the pursuit of explanatory depth which is very frequently taken to outweigh empirical inadequacies. This is the real intellectual revolution of the seventeenth century. (Chomsky 1978a, pp. 9–10)

A scientist aiming to frame deep explanatory principles is not well served merely by collecting surface data, since their relation to underlying structure is typically quite indirect. Most of the phenomena we ordinarily observe are the result of interaction effects involving a huge variety of underlying systems, perhaps including interacting masses, frictional planes, biological creatures and perceptual processes. Any serious science must study each system largely in highly idealized isolation from the others (hence the "different disciplines" of science and the effort and expense of "controlled experiments").

Indeed, many of the crucial data for generative grammar are not to be found in everyday language use or corpora. Some are negative data, that is data about sentences that people seldom or never produce, since they are not ones that are generated by their language faculty. Others are structures that are infrequently used, such as a passive interacting with clausal embedding (see Baker, Chapter 10 of this volume, on such data). Generative research often relies on data that are only discovered in connection with the theories it is considering. Focusing on spontaneously produced utterances that have been pre-theoretically collected would significantly handicap inquiry.

This focus on crucial data is connected to Chomsky's most famous, but only initial idealization: his (1965, 4) distinction between "competence" and "performance."[5] In contrast to the Bloomfieldian concern with the actual use, or *performance* of language, Chomsky is interested in the underlying grammatical *competence* system, what he (1986) came to call the *I-language*,[6] and with what he argues is the innate system that allows an I-language to develop, Universal Grammar, UG. On his view, the I-language underlies linguistic parsing and production, but its principles may not be clearly manifested in particular instances of language use, which, again, involves the interaction of many factors: not only the parser or sentence production processor, but also memory and pragmatic inference systems, and, in production, the speaker's preferences, articulatory abilities, speech pragmatics and so forth. The involvement of this multitude of diverse factors is why Chomsky doubts performance is a fruitful domain for general theoretical insight:

> [A] formalized grammar, regarded as a predictive theory, is an idealization in at least two respects: first, in that it considers formal structure independently of use; and second, in that the items that it generates will not be the utterances of which actual discourse is composed. Actual discourse consists of interrupted fragments, false starts, laps, slurring, and other phenomena that can only be understood as distortions of an underlying idealized pattern. (Chomsky 1962, p. 531)

On this view, the use of language, like the trajectories of leaves or automobiles, is a massive interaction effect, far too complex to hope to cover with a single theory.

There are actually several claims historically associated with the Galilean method. We've touched so far only upon the methodological one concerning what scientists should seek. Galileo also thought that mathematics is "the language of nature," which scientists often assume to be mathematically elegant (see Koyré 1943, p. 336ff; Weinberg 1976). Although Chomsky (1983/2004, p. 154ff) also takes this view

seriously, it is secondary and independent of the point about idealization, which could of course be to mathematically inelegant systems. We'll return to it in Section 33.3.[7]

33.2.2 Superficial Generalizations and Explanatory Principles

Not every general truth is explanatory. Chomsky distinguishes between generalizations over data and explanatory principles and argues that the point of idealization is not to arrive at the former but to discover the latter (Chomsky 1978a, p. 23). Generalizations are useful, not because they offer insight into phenomena, but because they describe and make clearer the phenomena that we should try to explain in terms of deeper rules or principles.

For example, the philosopher of science, Nancy Cartwright (1983) notes a distinction between two sets of laws that both accurately capture an effect discovered by Faraday. The physicist, Francis Everitt,

> Distinguishes Airy's phenomenological [i.e. merely descriptively accurate] law from the later theoretical treatment of Lorentz, […] because the electron theory explains the magneto-optical effect and Airy's does not. Phenomenological laws describe what happens. […] For the physicist […] the distinction between theoretical and phenomenological […] separate[s] laws which are fundamental and explanatory from those that merely describe. (Cartwright 1983, pp. 1–2)[8]

A good example of the same issue in linguistics is afforded by "island constraints." In work by Ross and others in the 1960s and afterwards, it was discovered that there are a number of kinds of phrase from which constituents cannot be extracted. Compare (1b) and (1d) below. On generative accounts, (1d) is ungrammatical because *what* cannot be extracted from the clause *who saw what*. This is an instance of the generalization that *wh*-clauses resist extraction, but this is not a deep explanation. One wants to know why such phrases do not allow extraction, preferably in terms of a theory that also explains why various other kinds of constituents (e.g. subjects and adjuncts) are also islands.

(1) a. Anne knows [that Bill saw the getaway car].
    b. What does Anne know [that Bill saw ___]?
    c. Anne knows [who saw the getaway car].
    d. *What does Anne know [who saw ___]?

Syntacticians, foremost among them Chomsky (1973), have proposed grammatical principles such as subjacency to explain island phenomena. This is not the place to review the proposals (see Müller, Chapter 12 of this volume). The point here is rather that the principles proposed are all constraints on the kinds of computations (i.e., manipulations of representations) that the I-language is capable of, and they try to explain islands of apparently diverse types by isolating properties they share and showing that those properties block certain kinds of (movement) operations in the grammar.

33.2.3 Relation between Data and Theory

As noted above, if explanatory principles rather than data coverage are the aim, then the data that matter will be those that help to distinguish between theories. Here, too Chomsky's methodology is in accord with contemporary philosophy of science. As the

eminent philosopher of science James Woodward puts it, expanding on Bogen and Woodward's classic (1988):

> What matters is not that we be able to infer 'downward' to features of the data from theory and other assumptions; rather, what matters is whether we are able to infer 'upward' from the data (and other assumptions) to the phenomenon of interest. Data are scientifically useful and interesting insofar as they provide information about features of phenomena. (Woodward 2011, p. 168)

To take a famous example, the astrophysicist Arthur Eddington photographed stars visually near the sun during an eclipse and

> infer[red] *from* features of his photographs (and various background assumptions) *to* a value for the deflection of starlight [by gravity] rather than trying to infer or derive characteristics of the photographs from other assumptions. (Woodward 2011, p. 168 – his italics)

That is, Eddington did not aim to explain all of the data provided by his photographs. He was concerned with the crucial data that were predicted by Einstein's theory but not Newton's. As the philosopher Jerry Fodor aptly put it:

> What goes on in science is not that we try to have theories that accommodate our experiences; it's closer that we try to have experiences that adjudicate among our theories. (Fodor 1991, pp. 202–3)

Thus, generative syntacticians are not primarily concerned to explain all – or even a significant portion – of language use; rather, just crucial data that are predictable from their but not rival theories. Of course, once deep explanatory principles are understood, they can be used to shed light on surface phenomena, typically in conjunction with other theories. The paths of ordinary objects can in principle be predicted using Newton's laws in conjunction with assumptions about friction, wind speed and so on (although the calculations required are often prohibitively complex). Similarly, the growing understanding of I-language predicts certain facts about usage fairly directly – for example, except in papers on syntax, examples of certain island violations are seldom, if ever encountered – but they invite the investigation of more complex aspects of usage, e.g. the study of how language is processed in real time (see Kush and Dillon, Chapter 19 of this volume).

A worry many people have voiced is that generativists make a great deal of use of speakers' intuitions, and using such possibly unreliable intuitive verdicts as evidence can seem a dubious methodology. Speaker verdicts are however not being taken to afford any special *insights* into grammar. Rather, they are just *data*: readily observable facts about human reactions that, like any other data, might help to distinguish between theories. One could also note differences in reaction times or pupillary dilation: anything that would betray a distinctive reaction. In this respect, they are like subjects' reactions to illusions in vision experiments. Of course, a confound that can occur is the influence of a linguist's commitment to his or her theory, or a hearer's acquiescence to a linguist's claims. This is one reason why linguists routinely ask for the (repeated) verdicts of "naive" *native* speakers of a language.

Note that all such data could be subjected to controlled experiment, e.g. using Likert scale questionnaires. Recent studies have demonstrated high reliability between

linguists and large sets of experimentally controlled subjects, particularly ones, such as beginning cognitive science students, who have some conception of what is being asked but are not yet in thrall to any particular theory (see Gross, Chapter 35 of this volume, for discussion and references).

33.3 How the Galilean Style Works in Generative Linguistics

The Galilean style is manifested in linguistic research in two distinct ways. Per our discussion so far, it can be taken as primarily methodological in import; but, as we mentioned, it can also be taken as involving two ontological claims that are Galilean in flavor: that nature is mathematically organized, and that the underlying principles of nature are in some sense elegant or simple. The second of these claims in particular has been pursued in recent generative linguistics, but, again, it is independent of the methodological point: mere methodological idealization provides no guarantee that the underlying principles or system which it helps to lay bare will turn out to be particularly simple or elegant, although it does presume that they are simpler than the mass of surface phenomena.[9]

Strong claims of ontological simplicity seem to be what Boeckx (2006, p. 115) has in mind when he labels the Minimalist Program in generative syntax "Galilean" (on the Minimalist Program, see Alexiadou and Lohndal, Chapter 3 of this volume). They also seem to be behind what Chomsky (1995, 2000a, 2001) calls the Strong Minimalist Thesis, which holds that language is an optimal solution to the task of relating sound and meaning, that is, to satisfying demands imposed by the interfaces. This is the claim that the operations of the language faculty are as efficient as they could possibly be, given the role that faculty plays in cognition, a proposal reminiscent of claims of mathematical elegance in physics. However, not all Minimalists share this assumption. One leading theorist, Norbert Hornstein (2013), suggests that the goal of Minimalism is, or should be, rather to recast theories of syntax so that they postulate as little as possible that is proprietary to the language faculty. This version of Minimalism eschews strong ontological simplicity claims regarding the nature of the computational system, but is entirely compatible with the Galilean style as a methodology.

As we have discussed above, generative linguistics has been methodologically Galilean from Chomsky's early work onward. The primary example of this is what we referred to in Section 33.1 as Chomsky's most famous idealization, namely the competence-performance distinction. It's important to see, though, that idealization goes well beyond this distinction in guiding the work of linguists. In studying, say, a syntactic property, it is crucial to attempt to isolate this property not only from other aspects of cognition but also as far as possible from other parts of the linguistic system, such as lexical, semantic, phonological, morphological, and discourse properties, and even from other syntactic properties. Typically, generative syntacticians attempt to work with examples that hold all these other properties constant while putatively varying just in whatever syntactic property is at issue.

Other theorists may want to abstract and idealize in different ways for different purposes. Everything depends on how theoretically fruitful a particular idealization proves. In this respect, Chomsky's proposals have fared extremely well: several classes of previously unsuspected phenomena have been uncovered, including syntactic islands as discussed above, but also Binding, Control, and Raising phenomena (for discussion

see Hornstein 2013; D'Alessandro 2019). And, of course, his approach offers the beginning of an understanding of the extraordinary speed and stability with which children attain grammatical competence.

33.4 Criticisms of the Galilean Style in Linguistics

> To tell an Aristotelian not to bother about friction or air-resistance was like telling him to abandon the real world we all inhabit in favour of a mathematical fantasy. (Sharratt 1994, p. 74)

Most critics of Galilean idealizations have rather strong empiricist and externalist leanings. In theory they may agree that the objective of linguistics is to look for hidden internal structures that give rise to observable phenomena, yet they strongly prefer coverage of surface facts about language(s) and language use – echoing Carnap, Hahn, and Neurath's "there are no depths; there is surface everywhere" (1973, p. 306).[10] Many also take the object of study to be not I-language and the language faculty, but external languages as shared social objects that are partially learned by each speaker.

These critics' stress on the importance of surface facts sometimes amounts to a denial of the assumption that what we observe is determined by the grammar interacting with other factors: e.g. when Riemer writes (2009, p. 622): "A theory which often predicts the ungrammaticality of clearly acceptable strings, or often predicts the grammaticality of unacceptable ones, is in trouble." This claim rests on the assumption that acceptability is (very largely) determined by the grammar: i.e. that interpretation is (nearly) free of interaction effects – a very dubious assumption, given what is known about parsing and pragmatics. A different way to make the same point is to note that strictly speaking, theories of grammar by themselves do not predict facts about acceptability. Only in conjunction with various auxiliary assumptions about parsing and so on do predictions of acceptability emerge.

In this section, we will discuss some of the criticisms of the Galilean style in linguistics, beginning with two core claims made by critics: (i) good science does not ignore data, (ii) the drive for abstraction in generative research has lost sight of the huge linguistic diversity that is evident in the languages of the world.

Let us deal with the second issue first. This claim is often made, e.g. by Evans and Levinson (2009) and Haspelmath (2007). However, as Baker (Chapter 10 of this volume) makes clear, not only has there been a great deal of work on non-English-like languages in the history of generative linguistics, but this comparative work has been crucial for progress in the field, particularly since the emergence of the principles and parameters program in the 1970s. And conversely, the success of generativist syntax here makes at least a *prima facie* case for the need for abstraction in comparative work: that is, it seems that the Galilean approach has enabled scholars to probe the grammatical architecture of diverse languages in ways that would have been impossible without idealizing (Sheehan, Chapter 11 of this volume, provides several examples). Idealization does not diminish the significance of linguistic diversity; rather, it enables us to study it using ordinary scientific methodology.

The other major criticism is that generativists ignore data. We suspect that those making this complaint assume that the domain of data to be accounted for by linguistic theory is something given, which ought to be common ground among linguists. But as we've explained above, the data that matter are those that help us accept

or reject a theory or distinguish between theories. Thus, depending on what your research questions are, the data of interest will be substantially different. To return to our example, if a scholar is interested in studying the grammatical constraints on argument *wh*-movement in a given language, it is probably not especially relevant to study frequencies of occurrence (say, of different types of arguments) in a given corpus. So even though such data could be interesting with a different research question in mind, grammatical constraints on *wh*-dependencies can (it seems) be studied without any need to look at them. The same goes for other kinds of data, such as how these *wh*-dependencies are used in discourse. That is an interesting question, but (as far we know) not one that generative syntacticians need presently be interested in since such usage data do not currently look likely to shed light on the structure of our mental grammar. Obviously none of this should prevent others from using whatever frequency or usage data bear on their theoretical claims, and almost any data *could* be relevant to any theory (if it turns out that they do bear on a claim it makes),[11] but the mere fact that some generativists do not use particular kinds of data does not warrant accusations of data ignorance. To establish that, the critics would have to show that *data that are relevant to claims made by generativists* are being ignored (deliberately or negligently), and as far we are aware, they have not done so.

Another complaint is that generativists ignore computational parts of linguistics that the critics regard as having good data coverage, including Artificial Intelligence (AI) work with corpora, which is dismissed as "engineering solutions" (Chomsky 2000b). It is true that most generative syntacticians have not taken such work to be very useful for their research, but with good reason. It is largely concerned with dealing with written corpora for practical purposes of machine translation or data compression, not with the internal psychological issues, e.g., about acquisition or non-acceptability responses, that concern Chomsky. We've explained above why generativists are not in the business of explaining the diverse performance phenomena that a corpus captures. There's a second reason why the AI work strikes them as of limited relevance. AI might solve similar problems to human intelligence, but it generally does it differently, just as airplanes and birds do not fly in the same way. Contemporary "deep learning" algorithms appear to acquire linguistic generalizations very differently from humans, needing to be trained on vast input corpora (see Adger 2019, Chapter 8, for an accessible summary of the evidence).

One final objection is of broader scope. This is the claim that linguistics is not a science, or at the least not a hard science, and that the quest for physics-like exceptionless laws is quixotic, leading necessarily to distortion of the phenomena since they are intrinsically less hard-edged or clear-cut. (Riemer 2009, p. 630; Evans and Levinson 2009.) It sometimes seems that those taking this line simply haven't understood the idealizations that are being made in generative linguistics (see for example Harbour 2009, on Evans and Levinson's confused claims about number in Kiowa). Be that as it may, the arguments for this view, such as they are, tend to beg the question against idealization in science. The methodology will be judged by how fruitful it proves to be. This paper is not the place to discuss in detail the successes of Chomsky's program (among many chapters, see Cheng and Griffiths, Chapter 4 of this volume; Hornstein 2013; D'Alessandro 2019), but it is obviously relevant that there are no nongenerative explanations for many of the crucial data and generalizations of modern linguistics.

Endnotes

1 Some of the material in this chapter draws on Allott (2019) and Rey (2020 §1.1).

2 Such empiricist leanings are prevalent among corpus linguists and usage-based linguists (regarding whom, see Newmeyer, Chapter 18 of this volume) as well as those who explicitly describe themselves as empiricists (e.g. Chater et al. 2015).

3 Critics sometimes point out that that Galileo was more of an experimentalist than was thought by Koyré, whose seminal work from the 1950s seems to have influenced Chomsky on this point (see Riemer 2009, 627–628, and Sharratt 1994, pp. 75–79). Whatever the historians of science decide, there is obviously no argument here against Chomsky's methodology in linguistics. In any case, generativists don't oppose experimental work. Indeed psycho- and neurolinguistic work relevant to generative grammar has mushroomed in recent decades, largely driven by the advances made by theoretical syntacticians. (See Kush and Dillon, Chapter 19 of this volume; Zaccarella and Trettenbein, Chapter 20 of this volume).

4 On the Galilean style, see Galileo (1610/2016); Koyré (1943); Weinberg (1976); Chomsky (1978a, pp. 9–10); Chomsky (1978b, p. 14); Chomsky (1980, p. 218); Chomsky (2002, pp. 98–100).

5 Ferdinand de Saussure (1914/77) made a similar distinction between *langue* and *parole* (cf. Chomsky 1968/2006, pp. 17–18; 1986, pp. 32ff; see also Newmeyer 1986, p. 71, for differences between Saussure's and Chomsky's notions).

6 Chomsky's original term *competence* led to confusion between mere behavioral dispositions and the underlying system responsible for those dispositions. Note that an I-language is not an idiolect, but *a computational system*, i.e., not the sort of thing one might speak. On the I-language as a mental system, see Allott and Smith (Chapter 34 of this volume).

7 There is, of course, a difficult question in philosophy of science about the ontological status of the generalizations and laws reached by abstraction, but there is no reason to think this question is more problematic for linguistics than for physics, chemistry or biology. Views about the status of idealizations range from Nancy Cartwright's (1983) famous claim that they are false, albeit often useful and interesting, to Chomsky's view that "it is the abstract systems that you are constructing that are really the truth; the array of phenomena is some distortion of the truth because of too many factors" (Chomsky 2002, p. 99; see Frigg and Hartmann, 2020, for an excellent overview of the issues). Weinberg (1976, p. 28) claims that physicists "give a higher degree of reality [to] abstract mathematical models of the universe […] than they accord the ordinary world of sensation," but, again, such metaphysical claims are independent of the methodological one we are discussing here.

8 Of course, what is explanatorily deep needn't be only fundamental physics; cf. fn. 9 below.

9 A related issue concerns the relationship between unification of theories and reduction to a more fundamental theory (e.g. neuroscience), which Boeckx (2006, 131–133) discusses with reference to physics and biology. Reduction is one type of unification, but there are other types of unification that do not entail reduction, and the Galilean style is not committed to either.

10 Writing about science, of course. The idea that "nothing is hidden" in the mind has been a recurrent theme in work of various kinds of behaviorists, from Quine and Skinner to Wittgenstein and Ryle, and, even more recently, in non-behaviorists such as Dennett (1991, p. 461ff.) and Chater (2018) and (specifically with regard to Chomsky) Baker and Hacker (1984).

11 See Antony (2003).

References

Adger, D. 2019. *Language Unlimited: The Science Behind Our Most Creative Power*. Oxford: Oxford University Press.

D'Alessandro, R. 2019. The achievements of Generative Syntax: a time chart and some reflections. *Catalan Journal of Linguistics Special Issue* 7–26.

Allott, N. 2019. Scientific tractability and relevance theory. In K. Scott, R. Carston and B. Clark (Eds.), *Relevance: Pragmatics and Interpretation* (pp. 29–41). Cambridge: Cambridge University Press.

Antony, L. 2003. Rabbit-pots and supernovas: On the relevance of psychological data to linguistic theory. In *Epistemology of Language*, edited by A. Barber, pp. 47–68. Oxford: Oxford University Press.

Baker, G. and P. Hacker, P, 1984. *Language, Sense and Nonsense: A Critical Investigation into Modern Theories of Language*, Oxford: Blackwell.

Bloomfield, L. 1933. *Language*. New York: Henry Holt.

Boeckx, C. 2006. *Linguistic Minimalism: Origins, Concepts, Methods, and Aims*. Oxford: Oxford University Press.

Boeckx, Cedric. 2010. *Language in Cognition*. Wiley-Blackwell: Malden.

Bogen, J., and J. Woodward. 1988. Saving the phenomena. *The Philosophical Review* 97(3): 303–352.

Botha, R. P. 1982. On "the Galilean style" of linguistic inquiry. *Lingua* 58(1): 1–50.

Carnap, R., H. Hahn, and O. Neurath. 1973. The scientific conception of the world: The Vienna Circle. In *Empiricism and Sociology*, edited by M. Neurath and R. S. Cohen, 299–316. Dordrecht: Reidel.

Cartwright, N. 1983. *How the Laws of Physics Lie*. Oxford: Clarendon Press.

Chater, N. 2018. *The Mind Is Flat: The Illusion of Depth and the Improvised Mind*, New York: Penguin Random House

Chater, N., A. Clark, J. A. Goldsmith, and A. Perfors. 2015. *Empiricism and Language* Learnability. Oxford: Oxford University Press.

Chomsky, N. 1962. Explanatory models in linguistics. In *Logic, Methodology and Philosophy of Science*, edited by E. Nagel, P. Suppes, and A. Tarski, 528–550. Stanford, CA: Stanford University Press.

Chomsky, N. 1965. *Aspects of the Theory of Syntax*. Cambridge, MA: MIT Press.

Chomsky, N. 1968/*2006. Language and Mind.* 3rd ed., Cambridge: Cambridge University Press.

Chomsky, N. 1973. Conditions on transformations. In *A Festschrift for Morris Halle*, edited by S. Anderson, and P. Kiparsky, 232–86. New York: Holt, Rinehart & Winston.

Chomsky, N. 1978a. A theory of core grammar. *Glot* 1: 7–26.

Chomsky, N. 1978b. Interview with Sol Saporta. Washington State University, *Dept. of Linguistics Working Papers in Linguistics, supplement* 4: 1–26.

Chomsky, N. 1980. *Rules and Representations*. New York: Columbia University Press.

Chomsky, N. 1983/ 2004. The Generative Enterprise Revisited: Discussions with Riny Huybregts, Henk van Riemsdijk, Naoki Fukui and Mihoko Zushi (originally published in 1983 as The Generative Enterprise). Berlin: De Gruyter Mouton.

Chomsky, N. 1986. *Knowledge of Language: Its Nature, Origin, and Use*. New York: Praeger.

Chomsky, N. 1995. Language and nature. *Mind* 104 (413): 1–61.

Chomsky, N. 2000a. Linguistics and brain science. In *Image, language, brain: papers from the First Mind Articulation Project Symposium*, edited by A. Marantz, Y. Miyashita, and W. A. O'Neil, 13-28. Cambridge: MIT Press.

Chomsky, N. 2000b. Minimalist Inquiries. In *Step by Step: Essays on Minimalist Syntax in Honor of Howard Lasnik*, edited by R. Martin, D. Michaels, and J. Uriagereka, 89-155. Cambridge: MIT Press.

Chomsky, N. 2001. Derivation by phase. In *Ken Hale: A Life in Language*, edited by M. J. Kenstowicz, 1–52. Cambridge, Mass: MIT Press.

Chomsky, N. 2002. *On Nature and Language*. Cambridge: Cambridge University Press.

Chomsky, N., and J. Andor. 2005. The master and his performance: An interview with Noam Chomsky. *Intercultural Pragmatics* 1(1): 93–111.

Chomsky, N., R. Huybregts, and H. C. V. Riemsdijk. 1982. Noam Chomsky on the Generative Enterprise: A Discussion With Riny Huybregts and Henk Van Riemsdijk. Dordrecht, Holland; Cinnaminson, N.J: Foris Publications.

Dennett, D. 1991. *Consciousness Explained*. Boston: Little Brown & Co.

Evans, N., and S. C. Levinson. 2009. The myth of language universals: language diversity and its importance for cognitive science. *Behavioral and Brain Sciences* 32(5): 429–448.

Fodor, J. A. 1991. The dogma that didn't bark (a fragment of a naturalized epistemology). *Mind* 100(2): 201–220.

Freidin, R., and J-R. Vergnaud 2001. Exquisite connections: some remarks on the evolution of linguistic theory. Lingua 111: 639–666.

Frigg, R. & Hartmann, S. 2020. *Models in science*. Stanford Encyclopedia of Philosophy. https://plato.stanford.edu/entries/models-science/

Galilei, G. 1610/2016. *Sidereus Nuncius, or The Sidereal Messenger*. Translated with Commentary by Albert van Helden. Chicago: University of Chicago Press.

Harbour, D. 2009. The universal basis of local linguistic exceptionality. *Behavioral and Brain Sciences* 32 (05): 456–457.

Haspelmath, M. 2007. Pre-established categories don't exist: Consequences for language description and typology. *Linguistic Typology* 11 (1): 119–132.

Hornstein, N. 2013. Three grades of grammatical involvement: Syntax from a Minimalist perspective. *Mind & Language* 28 (4): 392–420.

Knight, C. 2016. *Decoding Chomsky: Science and Revolutionary Politics*. New Haven and London: Yale University Press.

Koyré, A. 1943. Galileo and the scientific revolution of the seventeenth century. *The Philosophical Review* 52 (4): 333–348.

McMullin, E. 1985. Galilean idealization. *Studies in History and Philosophy of Science Part A* 16 (3): 247–273.

Newmeyer, F. J. 1986. *Linguistic Theory in America* (2nd ed.). Orlando: Academic Press.

Pietroski, P., and G. Rey. 1995. When other things aren't equal: Saving Ceteris Paribus. *British Journal for the Philosophy of Science* 46: 81–110.

Rey, G. 2020. *Representation of Language: Philosophical Issues in a Chomskyan Linguistics*. Oxford: Oxford University Press.

Riemer, N. 2009. Grammaticality as evidence and as prediction in a Galilean linguistics. *Language Sciences* 31 (5): 612–633.

Sampson, G. 1980. *Schools of Linguistics: Competition and Evolution*. London: Hutcheson.

Seuren, P. A. M. 2004. *Chomsky's Minimalism*. Oxford: Oxford University Press.

de Saussure, F. 1914/77. Cours de linguistique générale, ed. C. Bally and A. Sechehaye, with the collaboration of A. Riedlinger, Lausanne and Paris: Payot; trans. W. Baskin, Course in General Linguistics, Glasgow: Fontana/Collins, 1977.

Sharratt, M. 1994. *Galileo: Decisive Innovator*. Oxford: Blackwell.

Weinberg, S. 1976. The forces of nature. *Bulletin of the American Academy of Arts and Sciences* 29 (4): 13–29.

Woodward, J. 2011. Data and phenomena: a restatement and defense. *Synthese* 182: 165–179.

34

Chomsky and Fodor on Modularity[1]

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34.1 Introduction: Conceptions of Modularity

The philosopher Jerry Fodor was a key figure alongside Chomsky in the revolution that led to the renaissance of the cognitive sciences from around 1960. They both argued forcefully for the central postulate of the cognitive revolution: serious study of the mind requires investigation of its internal structures. Both are also vocal advocates of nativism, the view that our mental capacities are to a considerable degree innately determined. And they agree on the importance of Alan Turing's work on computation,[2] since it points the way to rigorous theories of mental capacities in terms of computations that manipulate mental representations.[3] Their work was instrumental in the demise of behaviorism and similar views that were dominant in psychology and philosophy of mind in the mid-twentieth century. However, Chomsky and Fodor differ on Fodor's two best-known contributions to cognitive science. Fodor (1975) argues there is a "Language of Thought" distinct from natural languages, while Chomsky's view is that much of our thought is conducted in natural language.[4,5]

In this chapter, we survey another key difference between Chomsky and Fodor. They have both argued that cognitive science should investigate the mind as a system composed of distinct components; indeed, their views are sometimes conflated as one "modularity of mind" hypothesis. However, their notions of modularity differ in ways that derive from their commitments to distinct programs of research.

Chomsky envisages that fruitful study will focus on domain-specific mental systems which are largely innately specified, each of which underlies a particular ability and

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is characterized by proprietary principles, and that to investigate these systems it is necessary to abstract away from most of the complications in how they are put to use (1975; 1980a; 1980b). Such systems are what Chomsky means when he uses the terms "module," "modularity" (e.g. 1980b, pp. 3, 15) or "modular" (e.g. 1984)[6] – although he generally prefers other terms, particularly "faculty" and "mental organ." They have also been called "analytic modules" and "competence modules." A central example of such a system is the language faculty, a system which, interacting with other mental systems including the sentence parser, memory and conceptual systems, enables our linguistic performance. Other candidates include the number sense[7], moral "grammar",[8] and the systems underlying intuitive (folk) biology[9] and physics.[10]

In contrast, Fodor focuses on processing. He argued (1983) that input and output processing, including early visual processing, sentence parsing, and the production of motor commands, are carried out by dedicated, automatic, domain-specific processing units, which he called "modules." Crucially, these modules are encapsulated: that is, their workings are insulated from information that is held elsewhere in the mind. The central claim here is that there are some mental processes that work bottom-up and are impervious to influence from above: their output is not affected by the agent's beliefs and desires. When the term "module" is used in philosophy of mind, Fodor's notion of an encapsulated processing unit is taken as the starting point.[11]

A third use of "module" is common in cognitive science and evolutionary psychology. Here, as in Fodor's conception, a module is a domain- or task-specific mental processing unit which is architecturally distinct from other processing units. But this use of "module" differs from Fodor's in one key respect: encapsulation from general beliefs is not necessary.[12]

An alternative to all these views is that the mind does not have modular structure in any of these senses. In cognitive science this perspective goes back to "connectionist" work by Rumelhart and McLeland (1986) and it has enjoyed a resurgence in popularity with the arrival of "big data," especially neurological data (e.g. Plaut 2003; Zerilli 2019).

In this chapter we concentrate on Chomsky's and Fodor's conceptions of modularity. We discuss two ways of understanding Chomsky's proposal, in particular how it claims an underlying faculty is related to processing and performance. We observe that Chomsky is largely agnostic on this question; the commitments of his programme are to be found elsewhere.

In section 34.3, we also review the evidential foundation of all versions of modularity: double dissociation (impairments of one or more mental abilities caused by accidents or other pathology which leave other abilities intact). While there is considerable evidence for modularity, the data currently available are largely neutral, we argue, as between Chomsky's and Fodor's notions.

34.2 The Two Programs

34.2.1 Fodorian Modules: Encapsulated Processing Units

Fodor's notion of a cognitive module, influenced by but distinct from Chomsky's (Fodor 1983, pp. 3–10), was set out in his famous monograph *The Modularity of Mind* (1983), and somewhat modified in his *The Mind Doesn't Work That Way* (2000). For him, a module is a discrete processing system, where this discreteness largely comes down

to informational encapsulation (1983, pp. 37, 71). That is, in processing an input, a module cannot draw on just any information held in the mind. The classic examples of such encapsulation are optical illusions such as the Müller-Lyer diagram. A belief that the lines are the same length – e.g. because you have measured them – does not stop one of them from "looking" longer than the other. On Fodor's view, this is evidence that the relevant aspect of visual processing is encapsulated, at least with respect to "central" or "person-level" beliefs (i.e. it is not "cognitively penetrated" – see below).

In addition to informational encapsulation, modules typically also have the following properties (Fodor 1985, p. 14)[13]:

- *Domain specificity*: Each module can only operate with a certain type of input. This could be input from one sense – e.g. visual or auditory – or more fine-grained within a sensory modality – e.g. color perception or edge detection – or cross-modal but still domain-specific, as with linguistic parsing, which operates on auditory and visual stimuli.
- *Automaticity* and *involuntariness*: Modules are reflex-like, triggered into action by input that falls within their domain.
- *Speed*: Modules are typically fast. Fodor suggests that this is because they are encapsulated, so processing some input does not trigger a lengthy search in general memory for relevant information; and because they operate automatically: a module, once triggered into action, implements a given procedure with no deliberation over what would be the best way to process each input.
- *Functional localization*: A module is subserved by a dedicated region or regions of the brain, or, more subtly, by dedicated neural circuits, even if they happen to be quite widely distributed across the brain and/or physically entangled with circuits that do other jobs.
- *Innateness*: At least some modules are innately specified.[14] Note that this claim does not preclude environmental effects on the way that modules develop. They may well need suitable conditions to develop, where this obviously includes suitable nutrition, as well as some perceptual input, as in language acquisition. (See Fodor 1985, pp. 35, 36; Sheehan, Chapter 11 of this volume.)

Working with this conception of modularity, Fodor makes two claims: (1) that peripheral cognition is modular, and, (2) that central cognition, in particular the fixation of belief, is nonmodular. Peripheral processing includes perception and linguistic parsing, and central processing is concerned with reasoning and decision making. According to this model of the mind, the senses are connected to transducers, which convert the energy of incoming stimuli into a format that can be used in computation. Their output goes to the input modules, which take care of visual and other perceptual processing and sentence parsing. Some of the outputs of these modules may feed other modules, but others send their output to central cognition where they are combined in all-things-considered belief formation and decision making. For decisions that result in action the model looks the same in reverse: the decision activates an output module e.g. a module dealing with language production or motor action and these send appropriate signals via transducers to muscles.

The task of a perceptual module is to process a stimulus to construct a representation of the aspect of the world that caused it (e.g. an uttered sentence or visual scene). The sensory input underdetermines the representation that the module

constructs: there are many arrangements of objects that could have caused any pattern of retinal stimulation, and, given structural and lexical ambiguity, many sentences that could have given rise to any string of speech sounds. This implies that visual perception and linguistic parsing both involve nondemonstrative inference and that information that is not in the sensory stimulus has to be brought to bear.

Fodor's innovation was to point out that this does not entail that everything known to the agent can be used. Rather, he suggested, each module can only make use of a domain-specific body of information: in parsing, the grammar[15] and some lexical information; in vision, "assumptions" such as the rigidity principle, which means that a retinal line varying in length is more likely to be construed as due to a rotating object than one growing and shrinking.

There are good reasons for the mind to be this way, Fodor claims. On his account, perception is much faster than it would be if it accessed central beliefs, and it will not ignore evidence for an occurrence because of a prior belief that the event is unlikely. These advantages come with a cost: an increased prevalence of false positives. Fodor argues that price is worth paying: a modular architecture is ecologically rational given that "[p]erception is built to detect what is right here, right now – what is available, for example, for eating or being eaten by" (Fodor 1985, p. 4).

A number of refinements and caveats need to be mentioned. Although some encapsulation is criterial for a Fodorian module, encapsulation need not be absolute. In particular, some cross-talk between modules is allowed for, as in the McGurk effect, a phenomenon which shows that visual and auditory cues are integrated in processing speech. For example, a video of the face of a speaker saying [b] overdubbed with the speech sound [g] is perceived as [d].[16]

What Fodor's conception of modularity rules out is "cognitive penetration" (Pylyshyn 1984): information from central cognition cannot become available to peripheral modules "top-down." Knowing about an illusion such as the McGurk effect or the Müller-Lyer lines does not render one immune to it. Fodor's explanation is that the beliefs the central system holds about perception do not affect the processing or output of the perceptual modules.

A further caveat about Fodor's criteria is that automaticity need not be absolute. There is nothing incoherent about a module failing to operate because it is in some way inhibited, as is obvious if we compare modules with noncognitive reflexes. Some of these can be consciously suppressed, including the cough reflex and saccades of the eye. So the claim about automaticity of modules must be about normal operation in the absence of interfering factors. An analogue is the existence of "threshold" effects. For instance, a drug may elicit no response at low dosages but, once a particular level – the threshold – is reached may cause significant effects. (Colman 2015).

Fodor's work has been a spur to a great deal of research on whether perception, particularly visual processing, is cognitively penetrated.[17] There have been many claims that top-down effects on perception have been found. For example, there is evidence that it is easier to recognize an object when it is in a context where it would be expected (Bar 2004, 2007). However, a recent review of the literature argues that owing to errors in either methods or analysis "[n]one of these hundreds of studies – either individually or collectively – provides compelling evidence for true top-down effects on visual perception" (Firestone and Scholl 2016, p. 1).

The crucial disagreements here are not about the data but what they show. In vision, what is processed depends on what one is looking at, and that is under central control. There is ongoing debate about whether other top-down influences are similar or whether they change the *way* in which stimuli are processed.[18] Only the latter would be in conflict with Fodor's conception of modularity. At present the balance of evidence is that visual processing is modular to a considerable degree, even if there is some cognitive penetration.

It is less clear what to say about language processing, Fodor's other example of a peripheral module, given that comprehension includes pragmatic inference, which can draw on any information. Disambiguation, assignment of referents to indexicals, and enrichment require inference about the speaker's intentions, what the speaker could have expected the addressee to know etc. Debate has largely focused on whether syntactic parsing is encapsulated. (Pickering and van Gompel 2006 provide a survey.) Ferreira and Nye (2017) have recently argued that reports of the death of modularity in this area have been exaggerated.

If the mind is modular in Fodor's sense then perception and domain-general reasoning are distinct architecturally – obviously a major discovery in cognitive science. Fodor's work was also motivated by wider, anti-relativist, implications (Fodor 1984, 1985, p. 5). In epistemology it promises to dispel the awkward question raised by a nonmodular view of perception: If what you perceive is shaped by what you believe or desire, then why should you trust your perceptions? In philosophy of science a modular view argues for the possibility of a common stock of observational data between those who subscribe to different theories (Fodor 1984, pp. 38, 41–42), contra claims by some that all data are theory-laden and therefore different theories are incommensurable and rational theory-choice impossible (e.g. Kuhn 1962).

34.2.2 Chomsky: Competence Modules, Analytic Modules, and Mental Organs

For Chomsky, a mental organ, faculty or module (1975; 1980a; 1980b; 1984; 1995; 2017) is a cognitive structure underlying performance in some domain: a distinct component of "mental architecture," with its own developmental pathway and organized according to proprietary principles.

The classic example is the language faculty, a domain-specific mental organ whose innate component, Universal Grammar (UG), both enables and constrains the development of mature linguistic competence, I-language: the "mental grammar" that underlies use of language. Competence here stands in contrast to "performance," i.e. episodes of cognition and behavior. (On this idealization, see Allott, Lohndal and Rey, Chapter 33 of this volume.)

For cognition more generally, Chomsky postulates that underlying some human cognitive abilities there are distinct mental faculties, whose mature state is determined to a considerable degree by domain-specific innate endowment: the equivalent of UG for each domain. This comes with connected claims about methodology: that it is necessary to abstract away from much of the complexity of performance, since it results from the interaction of many mental systems and is therefore too complex to be captured by systematic theories; that cognitive scientists should focus on computational accounts of mental faculties; and that cognitive science is more likely to discover deep, explanatory theories of domains where there is such an innate faculty to be found.

Note that Chomsky does *not* see such mental organs as collections of mentally represented propositional information (Chomsky 2017, pp. 34–35), although others have taken this to be the essence of his conception (e.g. Fodor 1983; Segal 1996; Knowles 2000). Consider again the rigidity principle in vision. There are two ways that it could work. The principle could (1) be stored as an item of knowledge in a database whence visual processing retrieves it to use, perhaps as a premise in inference, or (2) visual processing could be so constituted that it respects this principle without representing it as such.[19] On the second view, the system is simply disposed to treat stimuli as though they were caused by rigid objects. Compare with the laws of cell division: they are not written in cells; rather they are generalizations that describe the process. Chomsky's view of the I-language is like this. The principles that syntacticians discover are true of it, but not stored as propositional information within it.

This distinction became clearer with the development in syntactic theory of the Principles and Parameters framework (on which see Alexiadou and Lohndal, Chapter 3 of this volume). Earlier theories had relied on syntactic rules (as an ambition rather than an achievement), but these were now replaced by principles. It's hard to define the distinction rigorously – the terms have been used in several partially overlapping ways by working linguists – but there are two key differences. First, it is natural to see them as architectural features of the system rather than stored data; to say that UG has a particular principle is just to say that any possible I-language will be so constituted as to obey that principle. This is related to the second difference (historically of more importance in the development of syntactic theory): principles are hypothesized to be systemwide, whereas rules are specific to particular constructions or domains.

There was another use of the term "module" in Government and Binding (GB) era generative syntax. Sentences were only well-formed if they conformed to several distinct types of constraint: verbs must have the right number of arguments in the right structural positions; reflexive pronouns must be bound; DPs must be assigned abstract case, and so on. GB grammars were modular in that they postulated a distinct sub-system within the I-language for each type of grammatical property (Chomsky 1981; Curtiss 2013, pp. 80–90; Hornstein 2013, pp. 398–399; Smith and Allott 2016, pp. 80–93). One of the aims of Minimalism, Chomsky's program for syntactic research from the early 1990s on, is to account for GB-era generalizations in a framework which eschews such sub-systems (see Alexiadou and Lohndal, Chapter 3 of this volume).[20]

Returning to the larger picture, there are at least two ways mental organs have been understood, related to different views of the competence-performance distinction. On the first view, claims about competence are completely independent of claims about processing. This is suggested by certain fundamental assumptions of generative grammar. The sense in which a generative grammar "generates" is mathematical and atemporal.[21] To say that the I-language generates a certain structure by (e.g.) merging *eat* and *cake* and then merging the result with *we* is not to claim that there is a time at which the phrase [*eat cake*] exists but the sentence [*We eat cake*] does not. The ordering of the rules is rather to capture facts about constituency: [*eat cake*] is a constituent of the sentence, while *we eat* is not (see Adger, Chapter 8 of this volume). This is in contrast to theories of parsing, which explicitly try to capture the temporal stages in which a representation is built up as a sentence is heard. This might suggest a view of the competence-performance distinction on which theories of grammar do not make any claims about mental *processes* and thus make no causal claims.

There are two problems. The first is that this view is hard to reconcile with the goals and practice of linguists. Linguists say that a certain sequence of words is acceptable (/unacceptable) or has a certain interpretation *because* the I-language has certain properties, which e.g. allow or block a certain configuration or a certain kind of movement. This is a claim that the I-language is causally responsible (at least in part) for the (un)acceptability and the interpretations available.

The second problem is that it's not clear that a non-process view of competence is compatible with the standard view in generativism described above, that grammatical rules/principles are instantiated by the system and not in general stored as items of knowledge. A visual processing system can be seen to respect the rigidity principle, for example, because of the way it treats input: roughly it maps certain "ambiguous" configurations onto representations as of a rigid rotating object. It's hard to see how this kind of criterion could apply to a system that doesn't itself process anything.

A different conception of the competence/performance distinction stresses instead that mental organs like the I-language are mental systems that are accessed in performance by input and output systems such as the sentence parser: "the cognitive system of the language faculty is accessed by such systems, but is distinct from them" (Chomsky 2000a, p. 117). This view is a better fit with the features noted above of linguists' talk: that the (un)acceptability of a sentence is because it is/isn't generated by the grammar, that it has a certain kind of interpretation because the grammar assigns it a certain structure and so on, and is compatible with the view that some or all grammatical principles need not be stored in a database, but merely instantiated by the dispositions of the I-language system.[22] This view obviously raises the question: what kind of processing do the competence faculties do? See Phillips (2013), Smith and Allott (2016, pp. 152 ff.), Adger (Chapter 8 of this volume) for discussion and references to recent work in this area.

In fact, Chomsky is mostly agnostic about how the I-language interacts with other systems. His commitments here are just that there is a cognitive system that is the object described by grammatical theory and that it is accessed by performance systems, allowing parsing and production.

The other commitments of Chomsky's faculty view of the mind include the following:

1. Mental faculties are *analytic* modules. They are distinct cognitive systems that can be fruitfully investigated in abstraction from other faculties and processing systems.[23] Compare with Galileo and Newton on falling bodies. They assumed that there is some underlying explanatory structure in nature that can be theorized about, and that is simpler than the phenomena observed. We may never see the system working in isolation, since plausibly all actual phenomena are the result of the interaction of more than one system: e.g. gravity, air friction, wind. Similarly with mental systems: exercise of the I-language may always involve some combination of parsing or production, pragmatic ability, and various memory systems. But it can be theorized about independently of them because it is characterized by proprietary principles (see Allott, Lohndal and Rey, Chapter 33 of this volume).
2. There are domain-specific constraints on acquisition. UG allows only a tiny fraction of the languages that are logically possible (see Crain and Thornton, Chapter 21; Crain, Giblin and Thornton, Chapter 29 of this volume). It is not a general-purpose learning device (Collins 2002, pp. 128, 135), but has an innate

proprietary vocabulary – e.g. N(oun) and V(erb) – and it construes input in such terms. Likewise for other mental faculties such as the number sense. In each case, the mature adult state of a faculty might be invariant, or could vary depending on the input (as with I-language) or other factors.

3. Such faculties are species-universal. In practice, this is important to investigation: it justifies the use of data from individuals across cultures, and such comparisons help to isolate the genetic endowment. It also seems to be true. As far as we know, all developmentally normal children are able to acquire any language with approximately equal facility, and the same appears to be true for the number and moral senses. On the other hand, this property is not fundamental to the concept of a faculty. It's not incoherent to imagine an individual with a unique faculty (or an extra limb), such as the ancestral human in whom, Berwick and Chomsky speculate, "the generative procedure [for language] emerged suddenly as the result of a minor mutation" (Berwick and Chomsky 2016, p. 70). In principle, one could study the faculties of individuals or sub-species if they varied.

34.2.3 Comparison of Chomsky's and Fodor's views

As Fodor noted in introducing his conception of modularity, his view is compatible with Chomsky's (Fodor 1983; see also Chomsky 2017, p. 34). Fodor's claims are about processing; Chomsky's are about analytic/competence units. The language faculty as generativists conceive it is a discrete system that is accessed by both input (parsing) and output (production) systems, and is itself neither an input nor output module: as Chomsky says, no one speaks only Japanese and understands only Swahili. There is no clash with Fodor's claim that central processes are not modular given that the language faculty is not a processing system.

Conversely, Chomsky's program makes no claim about Fodor's view that some aspects of processing are encapsulated. Linguistic parsing could in principle make use only of domain-general processing abilities such as statistical inference or be carried-out by domain-specific but cognitively penetrated systems, while still drawing on language-specific resources provided by the I-language.[24,25] Equally, there could be dedicated, encapsulated modules for sentence parsing and production.

Nonetheless there is a difference in emphasis between Fodor and Chomsky's views of language. In contrast to Fodor's focus on parsing, Chomsky's view is closer to a historical tradition in grammar that saw *production* as primary. Indeed he is sometimes interpreted as holding a "speaker-oriented" view of language. Note, though, that Chomsky distinguishes clearly, as the older tradition did not, between the generative competence, which is the focus of his research, and production, which is an aspect of performance (Chomsky 2017, p. 26).

34.3 Evidence

34.3.1 Examples

The most persuasive evidence for Fodorian modules, as for Chomskyan faculties, comes from dissociations. (Chomsky 2000a, 121; Collins 2002, pp. 135–136; Smith 2003, 2011). Dissociation does not entail modularity, but modularity does entail possible (double) dissociation (cf. Smith 2003, p. 89). This is true for both Chomsky and Fodor, although in Chomsky's case where we are dealing with a competence system, accessing

the evidence for this parallelism presupposes the operation of a set of (sets of) rules of a kind characteristic of Fodor's position. A difference might arise in principle if it is the mode of access to the knowledge stored in that module which is damaged, not the knowledge itself.

That one can be blind without being deaf or deaf without being blind shows that blindness and deafness are independent senses. Even if both conditions may in certain cases be caused by a defect in or damage to a single organ – the brain – the double dissociation shows uncontroversially that each is independent of the other. A similar simple example is found in aphasia with the independent risk of losing either one's phonological ability while the syntax is unaffected or vice versa. This also shows that the language faculty is not a monolithic structure but is fractionated into sub-modules – even if not to the extent in GB theory (see above). Neuro-psychological pathologies may likewise doubly dissociate as in the case of prosopagnosia and Capgras' delusion. In prosopagnosia one loses the ability to recognize faces, leading to sufferers exhibiting bizarre behaviour of the kind documented in the title case study of *The Man Who Mistook His Wife for a Hat* (Sacks 1985). In Capgras' delusion the sufferer can recognize faces appropriately but, because of the absence of any associated emotional response, is simultaneously convinced that the person recognized is an impostor.

Despite the simplicity of such examples some caution in appealing to them is necessary. First, it is important to distinguish single from double dissociation. For instance, Smith (1989, Chapter 4) documents the case of his toddler son who pronounced *puddle* as "puggle" ([pʌgəl]), presumably because he just couldn't say [pʌdəl]. As he demonstrably knew what a puddle was this looked like a simple dissociation between perception and production. But at the same stage of development he pronounced *puzzle* as "puddle" ([pʌdəl]), and was perfectly capable of correctly identifying adult utterances of each. This phenomenon made it clear that his pronunciation [pʌgəl] was not just a failure of production but must involve his perception as well; i.e. it reflected a double dissociation not just a single dissociation.

Second, the most striking modular effect occurred in the investigation of the polyglot *savant*, Christopher. (Smith and Tsimpli 1995, Smith et al 2011, Smith and Tsimpli, Chapter 23 of this volume). On a variety of tests, Christopher manifested a striking asymmetry between his general intelligence and his linguistic proficiency in some 20 or so languages. As part of the project, Smith and colleagues taught him and some undergraduate controls an invented language (Epun) deliberately designed to have impossible rules. These were, for example, structure-independent rules that necessitated counting the number of words. (On the types of rules allowed by UG, see Adger, Chapter 8 of this volume.) The hypothesis was that Christopher would fail to cope with these examples but that the controls – because of their superior general intelligence – would be able to solve the problem as a logical puzzle. The first half of the hypothesis was confirmed: Christopher failed to learn the rules. But so did the undergraduates! In an environment where language-learning was the focus, none of them managed to work out what was going on, although all of them (but not Christopher) could solve comparable counting problems presented as explicit puzzles. The language module disallows counting, so in language-learning no such hypothesis was entertained.

On the assumption that Christopher's difficulties were not specific to input or output, but related to language in general, this is a double dissociation within central cognition, and thus evidence for a Chomskyan competence module. One might think that such fractionation of central cognition is problematic for Fodor's view that central

cognition is nonmodular and unstructured, but it's important to remember that Fodor assumes that Chomsky is right that there are competence systems, in particular I-language. Fodor's modularity and nonmodularity theses only concern processing systems.

34.3.2 Alternatives

Thoroughly nonmodular views of cognition, such as connectionism, are still held. But as a theory of linguistic ability, connectionism is too weak and too strong. Connectionist and "deep learning" machines detect patterns that humans can't. A striking example is provided by the experiment on Christopher and undergraduate controls with impossible languages containing structure-independent rules. Moreover, AIs that have been "successful" in language-learning have been fed millions of sentences explicitly notated with structure. This is not the experience of the typical two-year-old. If one is interested in gaining insight into the human mind, rather than obtaining particular results to achieve engineering goals, then connectionism seems to be a dead end (Smith and Allott 2016, pp. 177ff.; Adger 2019, Chapter 8).

One influential alternative to Chomsky and Fodor's concepts of modularity was Annette Karmiloff-Smith's (1992) proposal that the relevant notion was "modularization." She did not dispute modularity as such but denied that it was innate. Her view was that the infant brain starts out equipotential and a modular structure emerges on the basis of experience. That is, her book was attempting to undermine the innatist conclusions that Chomsky and Fodor drew from their work, not attack the modular ontology they largely shared (see Smith 1994 for discussion). Similar remarks pertain to Karmiloff-Smith's and others' attempts (e.g. Elman et al 1996) to use the plasticity shown in normal development as an argument for the equipotentiality of the neonate brain and *a fortiori* against modularity (see Ambridge and Lieven 2011 for discussion). Even on the connectionists' own terms, it is not obvious that plasticity raises any kind of problem for either Chomsky or Fodor. As Smith and Allott put it (2016, p. 181): "the very notion of plasticity presupposes that particular regions are, in the absence of pathological conditions, prespecified for particular (modular) functions." A corollary of this fact is that the normal course of (language) development is yet another example of the poverty of the stimulus (see Crain and Thornton, Chapter 21; Crain, Giblin and Thornton, Chapter 29; Gleitman, Chapter 7 of this volume).

Connectionists typically attempt to eliminate modules and modularity in general. A diametrically opposed position is taken by those who claim that the mind is "massively modular,"[26] i.e. that not only perceptual and motor processing is modular, but that "central," "cognitive" processes such as theory of mind, cheater-detection and other kinds of inference are carried out by modules. For such theorists, modules are functionally dissociable units each specialized for a certain kind of task, which may be innately specified. The notion of informational encapsulation is not criterial.

It is not very controversial that there are some such modules – or "quasi modules" (Tsimpli and Smith 1998's proposed label, to distinguish them from Fodorian modules), but a strong massive modularity thesis (SMMT) is highly controversial: that all mental processing, whether perceptual or "central," is carried out by dedicated task-specific systems. Whether this is so is outside the scope of this paper, given that SMMT is logically independent of Fodor's and Chomsky's modularity claims.[27]

However, Chomsky seems to be sympathetic to the view, saying: "My own personal impression […] is that talk of 'general inferential or problem-solving capacities' tends to be rather empty, and that when we investigate actual cases in one or another organism, we find that specific mechanisms are assumed" (Chomsky in Stemmer 1999, 395).

34.4 Conclusion

Fodor's and Chomsky's distinct conceptions of modularity are both alive and well in current research. Sensory processing and linguistic parsing involve fast, automatic, domain-specific systems which are largely innate. As we have discussed, there is ongoing debate about how much these systems are cognitively penetrated. On current evidence it seems safe to assume that the answer is that their workings are largely impervious to central beliefs and desires. If so, they are Fodorian modules.

Less conspicuously, Chomsky's conception of domain-specific competence modules that are innately specified has been at the heart of several successful research programs in cognitive science. Whether theory of mind and morality are modular in Chomsky's sense is still open to question, but folk biology, folk physics, and the number sense are well established competence domains. The language faculty is the most thoroughly explored and best supported module of all.

Endnotes

1 The authors would like to thank Terje Lohndal, Georges Rey, Amahl Smith, and Deirdre Wilson for their very helpful comments on drafts of this chapter.
2 E.g. Turing 1950.
3 Although Chomsky and Fodor use the term "mental representation" differently.
4 The medium of thought might be language's output to the conceptual system, LF, (Smith 1983, p. 12); or as Chomsky has suggested, at least some thought might also involve representations of speech sounds (Chomsky 2011; for discussion see Smith and Allott 2016, pp. 50–3). Note, though, that Chomsky also sees "language [as] optimized for the system of thought, with mode of externalization [i.e. as speech or sign language] secondary" (Berwick and Chomsky 2016, p. 75).
5 A further, related disagreement between Chomsky and Fodor concerns the nature of word meanings. See Glanzberg, Chapter 26 of this volume.
6 With obvious exceptions such as Chomsky (2017) where he contrasts his notion with Fodor's.
7 Dehaene 1998.
8 Dwyer 1999; Mikhail 2011.
9 Medin and Atran 1999; Solomon and Zaitchik 2012.
10 Baillargeon 2004.
11 E.g. in Robbins (2017), a useful survey article which also considers massive modularity, but remarkably fails to mention Chomsky.
12 Tsimpli and Smith (1998) proposed calling such modules "quasi-modules," and reserving the term "module" for Fodor's conception: encapsulated peripheral processing units. See also section 34.3.2 below.
13 On the relation of these properties to the essential feature of Fodorian modules, cognitive impenetrability, see Currie and Sterelny 2000, pp. 147–148.

14 Reading may be an example of a modularized ability (fast, automatic etc. in adults) for which there is no dedicated innate component.
15 Fodor suggests that modules of his type draw on Chomskyan competence modules. Unlike Chomsky, though, he understands the latter as databases, collections of propositional representations. See below.
16 This illusion is just one piece of evidence among many that visual and auditory information are systematically combined in processing of spoken language. Campbell and Dodd (1980; cf. Campbell and MacSweeney 2012) demonstrate that normal language users get up to 50% of their understanding from visual input.
17 See Prinz 2006; Firestone and Scholl 2016; Gross 2017; Robbins 2017, Section 2.
18 On cognitive penetration and attention, see Gross 2017.
19 One reason for the widespread confusion is that the term "represent" is polysemous and Chomsky and other generativists generally use it in a specialized sense (from mathematics) where a system represents a principle or rule just if it is truly described by it i.e. if it instantiates it. Thus, when a generativist syntactician asks whether the Binding principles are represented in I-language she is asking whether they are true and whether they are so in virtue of the I-language organ (rather than, e.g. being due to a distinct pragmatic module).
20 In contrast, Curtiss 2013, Section 5.3 presents evidence for "little modularity" (as she calls it).
21 See e.g. Chomsky 2000b, pp. 111–112.
22 The view that the I-language is accessed by performance systems is compatible with the model which Fodor (1983, pp. 3–10) and Segal (1996) (wrongly) attributed to Chomsky: I-language as a database of propositional rules which the parser consults. As discussed, this excludes what is now largely taken for granted, that rules/principles are instantiated rather than stored.
23 We differ here from McCourt (undated) who defines an analytically modular view as one on which "one simply hypothesizes that there is a cognitive subsystem that exhibits specialized operations and some degree of domain specificity."
24 Chomsky also need not be committed to automaticity – although he has sometimes speculated that all sounds are processed by the linguistic system (including, e.g. the sound of a squeaky door) this doesn't follow from his conception of faculties.
25 The statistical abilities of infants are remarkable in language as elsewhere, making it clear that this is a domain-general capacity (see e.g. Saffran et al 1996).
26 Key works include Sperber 1994 (which coined the term "massive modularity"), 2002; Cosmides and Tooby 1992; and Carruthers 2006a, 2006b.
27 For discussion, see Carruthers 2006b; Samuels 2006; Sperber 2002.

References

Adger, D. 2019. *Language Unlimited: The Science Behind Our Most Creative Power*. Oxford: Oxford University Press.

Ambridge, B., and E. V. M. Lieven. 2011. *Child Language Acquisition : Contrasting Theoretical Approaches*. Cambridge: Cambridge University Press.

Baillargeon, R. 2004. Infants' physical world. *Current Directions in Psychological Science* 13 (3): 89–94.

Bar, M. 2004. Visual objects in context. *Nature Reviews Neuroscience* 5 (8): 617–629.

Bar, M. 2007. The proactive brain: using analogies and associations to generate predictions. *Trends in Cognitive Sciences* 11 (7): 280–289.

Berwick, R. C., and N. Chomsky. 2016. *Why Only Us: Language and Evolution*. Cambridge, MA: MIT Press.

Campbell, R. and B. Dodd. 1980, Hearing by eye. *Quarterly Journal of Experimental Psychology* 32 (1): 85–99.

Campbell, R., and M. MacSweeney. 2012. Brain bases for seeing speech. In *Audiovisual Speech Processing*, edited by G. Bailly, P. Perrier, and E. Vatikiotis-Bateson, 76–103. Cambridge: Cambridge University Press.

Carruthers, P. 2006a. *The Architecture of the Mind : Massive Modularity and the Flexibility of Thought*. Oxford: Clarendon Press; Oxford University Press.

Carruthers, P. 2006b. The case for massively modular models of mind. In *Contemporary Debates in Cognitive Science*, edited by R. Stainton, 3–21. Oxford: Blackwell.

Chomsky, N. 1975. *Reflections on Language*. New York: Pantheon Books.

Chomsky, N. 1980a. *Rules and Representations*. New York: Columbia University Press.

Chomsky, N. 1980b. Rules and representations. *Behavioral and Brain Sciences* 3 (01): 1–15.

Chomsky, N. 1981. *Lectures on Government and Binding*. Dordrecht: Foris.

Chomsky, N. 1984. *Modular Approaches to the Study of the Mind*. San Diego, CA: San Diego State University Press.

Chomsky, N. 1995. Language and nature. *Mind* 104 (413): 1–61.

Chomsky, N. 2000a. *New Horizons in the Study of Language and Mind*. Cambridge: Cambridge University Press.

Chomsky, N. 2000b. Minimalist inquiries: The framework. In *Step By Step: Essays on Minimalist Syntax in Honor of Howard Lasnik*, edited by R. Martin, D. Michaels, and J. Uriagereka, 89–155. Cambridge, MA: MIT Press.

Chomsky, N. 2011. Language and the cognitive science revolution(s). [Lecture given at Carleton University, April 8, 2011.] Available at https://chomsky.info/20110408/

Chomsky, N. 2017. Two notions of modularity. In *On Concepts, Modules, and Language: Cognitive Science At Its Core*, edited by R. G. De Almeida, and L. R. Gleitman, 25–40. Oxford: Oxford University Press.

Collins, J. 2002. On the very idea of a science forming faculty. *Dialectica* 56 (2): 125–151.

Colman, A. 2015. *A Dictionary of Psychology* (4th edition) Oxford: Oxford University Press.

Cosmides, L., and J. Tooby. 1992. Cognitive adaptations for social exchange. In *The Adapted Mind: Evolutionary Psychology and the Generation of Culture*, edited by J. Barkow, L. Cosmides, and J. Tooby, 163–228. Oxford: Oxford University Press.

Currie, G., and K. Sterelny. 2000. How to think about the modularity of mind-reading. *The Philosophical Quarterly* 50 (199): 145–160.

Curtiss, S. 2013. Revisiting modularity: Using language as a window to the mind. In *Rich Languages From Poor Inputs*, edited by M. Piattelli-Palmarini, and R. C. Berwick, 68–90. Oxford: Oxford University Press.

Dehaene, S. 1998. *The Number Sense: How the Mind Creates Mathematics*. London: Allen Lane.

Dwyer, S. 1999. Moral competence. In *Philosophy and Linguistics*, edited by K. Murasugi, and R. Stainton, 169–90. Boulder, CO: Westview Press.

Elman, J. L., E. A. Bates, M. H. Johnson, A. Karmiloff-Smith, D. Parisi, and K. Plunkett. 1996. *Rethinking Innateness: A Connectionist Perspective on Development*. Cambridge, MA: MIT Press.

Ferreira, F., and J. Nye. 2017. The modularity of sentence processing reconsidered. In *On Concepts, Modules, and Language: Cognitive Science At Its Core*, edited by R. G. De Almeida, and L. R. Gleitman, 64–85. Oxford: Oxford University Press.

Firestone, C., and B. J. Scholl. 2016. Cognition does not affect perception: Evaluating the evidence for "top-down" effects. *Behavioral & Brain Sciences* 39 (e229): 1–77.

Fodor, J. A. 1975. *The Language of Thought*. New York: Crowell.

Fodor, J. A. 1983. *The Modularity of Mind: An Essay on Faculty Psychology*. Cambridge: MIT Press.

Fodor, J. A. 1984. Observation reconsidered. *Philosophy of Science* 51 (1): 23–43.

Fodor, J. A. 1985. Précis of *The Modularity of Mind. Behavioral and Brain Sciences* 8 (1): 1–42.

Fodor, J. A. 2000. *The Mind Doesn't Work That Way: The Scope and Limits of Computational Psychology*. Cambridge, MA: MIT Press.

Gross, S. 2017. Cognitive penetration and attention. *Frontiers in Psychology* 8 (221): 1–12.

Hornstein, N. 2013. Three grades of grammatical involvement: Syntax from a Minimalist perspective. *Mind & Language* 28 (4): 392–420.

Karmiloff-Smith, A. 1992. *Beyond Modularity: a Developmental Perspective on Cognitive Science*. Cambridge, MA: MIT Press.

Knowles, J. 2000. Knowledge of grammar as a propositional attitude. *Philosophical Psychology* 13 (3): 325–353.

Kuhn, T. S. 1962. *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.

McCourt, M. Undated ms. *Modularity and the semantics/pragmatics distinction.*

Mikhail, J. M. 2011. *Elements of Moral Cognition: Rawls' Linguistic Analogy and the Cognitive Science of Moral and Legal Judgment*. Cambridge: Cambridge University Press.

Medin, D. L., and S. Atran, eds. 1999. *Folkbiology*. Cambridge, MA: MIT Press.

Phillips, C. 2013. Some arguments and nonarguments for reductionist accounts of syntactic phenomena. *Language and Cognitive Processes* 28 (1–2): 156–187.

Pickering, M. J., and R. P. G. van Gompel. 2006. Syntactic parsing. In *Handbook of Psycholinguistics*, edited by M. J. Traxler, and M. A. Gernsbacher, 455–503. Boston: Elsevier.

Plaut, D. C. 2003. Connectionist modeling of language: Examples and implications. In *Mind, Brain, and Language: Multidisciplinary Perspectives*, 143–167. Mahwah, NJ: L. Erlbaum Associates.

Prinz, J. J. 2006. Is the mind really modular? In *Contemporary Debates in Cognitive Science*, edited by R. Stainton, 22–36. Oxford: Blackwell.

Pylyshyn, Z. W. 1984. *Computation and Cognition: Toward a Foundation for Cognitive Science*. Cambridge, MA: MIT Press.

Robbins, P. 2017. Modularity of mind. In *The Stanford Encyclopedia of Philosophy*, edited by N. Z. Edward, Metaphysics Research Lab, Stanford University. Available at https://plato.stanford.edu/entries/modularity-mind/

Rumelhart, D. E., and J. L. McClelland. 1986. *Parallel Distributed Processing: Explorations in the Microstructure of Cognition*. Cambridge, MA: MIT Press.

Sacks, O. 1985. *The Man Who Mistook His Wife for a Hat and Other Clinical Tales*. New York: Summit Books.

Saffran, J. R., R. N. Aslin, and E. L. Newport. 1996. Statistical learning by 8-month-old infants. *Science* 274 (5294): 1926–1928.

Samuels, R. 2006. Is the human mind massively modular? In *Contemporary Debates in Cognitive Science*, edited by R. Stainton, 37–56. Blackwell: Oxford.

Segal, G. 1996. The modularity of theory of mind. In *Theories of Theories of Mind*, edited by P. Carruthers, and P. Smith, 141–157. Cambridge: Cambridge University Press.

Smith, N. V. 1983. Speculative linguistics. (Inaugural lecture, published by University College London.)

Smith, N. V. 1989. *The Twitter Machine: Reflections on Language*. Oxford: Blackwell.

Smith, N. V. 1994. Review of Karmiloff-Smith, *Beyond Modularity: A Developmental Perspective on Cognitive Science*. *European Journal of Disorders of Communication* 29 (1): 95–105.

Smith, N. V. 2003. Dissociation and modularity: Reflections on language and mind. In *Mind, Brain, and Language: Multidisciplinary Perspectives*, edited by M. T. Banich, and M. A. Mack, 87–111. Mahwah, NJ: L. Erlbaum Associates.

Smith, N. V. 2011. Modularity. In *The Cambridge Encyclopedia of the Language Sciences*, edited by P. C. Hogan, 510–11. Cambridge: Cambridge University Press.

Smith, N. V., and N. Allott, 2016. *Chomsky: Ideas and Ideals*. Cambridge: Cambridge University Press.

Smith, N. V., and I.-M. Tsimpli. 1995. *The Mind of a Savant: Language Learning and Modularity*. Oxford: Blackwell.

Smith, N. V., I. Tsimpli, G. Morgan, and B. Woll. 2011. *The Signs of a Savant: Language Against the Odds*. Cambridge: Cambridge University Press.

Solomon, G. E. A., and D. Zaitchik. 2012. Folkbiology. *Wiley Interdisciplinary Reviews: Cognitive Science* 3 (1): 105–115.

Sperber, D. 1994. The modularity of thought and the epidemiology of representations. In *Mapping the Mind: Domain Specificity in Cognition and Culture*, edited by L. A. Hirschfeld, and S. A. Gelman, 39–67. Cambridge: Cambridge University Press.

Sperber, D. 2002. In defense of massive modularity. In *Language, Brain and Cognitive Development: Essays in Honor of Jacques Mehler*, edited by E. Dupoux, 47–57. Cambridge, MA: MIT Press.

Stemmer, B. 1999. An on-line interview with Noam Chomsky: On the nature of pragmatics and related issues. *Brain and Language* 68 (3): 393–401.

Tsimpli, I. M., and N. V. Smith. 1998. Modules and quasi-modules: Language and theory of mind in a polyglot savant. *Learning and Individual Differences* 10 (3): 193–215.

Turing, A. M. 1950. Computer machinery and intelligence. *Mind* 59 (236): 433–60.

Zerilli, J. 2019. Neural reuse and the modularity of mind: Where to next for modularity? *Biological Theory* 14 (1): 1–20.

35

Linguistic Judgments as Evidence

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35.1 Introduction

Linguistics research is filled with observations such as the following: "There are three green books on the table" is an acceptable sentence, but "There are green three books on the table" is not. Such judgments – as well as judgments about co-reference, ambiguity, pronounceability, and more – form a significant part of the evidence base for linguistics. This is in large measure due to Chomsky, whose work has exemplified the fruitfulness of such evidence and whose *Aspects of the Theory of Syntax* (Chomsky 1965, Chapter 1) is a *locus classicus* for theorizing about their status. The prominence of judgment data in contemporary linguistics is crucially tied to Chomsky's mentalist reconception of the field.

Judgment data were not completely absent prior to Chomsky's work. For example, field linguists did not always prescind from asking informants whether such-and-such was something they would say, and Chomsky's teacher Zelig Harris emphasized the importance for phonology of speakers' judgments concerning sound differences (Harris 1951). But the positivist, behaviorist, and structuralist positions that dominated American linguistics in the first half of the twentieth century tended to view the use of judgment data with suspicion and focused rather on produced sentences.

The methodological strictures in part arose in reaction to problems encountered in earlier introspectionist psychology (discussed in Section 35.3). But the focus on produced utterances reflected as well a particular conception of what languages are and thus what linguistics is about. Though linguists of this period differed in many ways, they shared a tendency to view languages as consisting in the totality of utterances speakers of that language can produce (an E-language in Chomsky's (1986) terminology); and much work focused on describing, analyzing, and taxonomizing languages so conceived – for example, the many Native American languages so apparently different from the Indo-European languages which were then more familiar to linguists. While such a conception does not of itself preclude the use of speakers' judgments (cf. the

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remarks on Devitt's (2006) views in Section 35.2), it is more naturally combined with an emphasis on corpus data, especially given the methodological scruples already mentioned.

Conversely, judgment data find a natural home in Chomsky's mentalist reconception of linguistics – a reconception, according to Chomsky (1966), that is in fact a recovery and development of earlier ideas about language. On this approach, linguistics aims, not just to describe linguistic products, but to provide a cognitive explanation of various of their distinctive features. One of Chomsky's core hypotheses is that there is an innately constrained computational procedure realized in the mind-brain – so-called I-language – that is implicated specifically in linguistic phenomena and whose character explains some of their distinctive features. As with aspects of our cognition more generally, we cannot directly observe I-language but must infer it from the effects to which it contributes. The methodological claim relevant to this chapter is that judgment data prove particularly useful in this endeavor.

This is so for several reasons. First, judgment tasks allow linguists to collect data concerning items that rarely show up in a corpus of actually produced speech – for example, perfectly fine sentences that are structurally a bit complex. Such sentences have proven useful for investigating particular phenomena and hypotheses. Judgment tasks, like any experiment, thus allow linguists to draw on data beyond what happens to occur naturally without intervention. Second, relatedly, judgment tasks can provide negative evidence regarding items that do not appear in the corpus specifically because they violate I-language constraints. Mere absence from a corpus can occur for any number of reasons. A judgment of unacceptability provides stronger evidence of ungrammaticality – insofar as reasonable alternative explanations can be ruled out (pragmatic oddity, processing difficulties, memory constraints, lexical awkwardness, etc.). This points to a third reason judgment data have proven useful. One can systematically vary the items presented in judgment tasks in ways that control for competing explanations. An inference back to the judgment's cause may then plausibly isolate features of I-language from among the various interacting aspects of cognition responsible for the judgment.

There is no claim that in principle *only* judgment data can serve this purpose. Indeed, in early work (Chomsky 1955/1975, pp. 101–103), Chomsky looked for behavioral measures that might serve instead. But as the efficiency and fruitfulness of judgment data became evident, they became the central source of evidence in theoretical syntax – a status they have retained, even as the evidential base of linguistics has broadened. Nevertheless, despite their success in allowing interesting phenomena to be identified, important questions to be raised, and substantial hypotheses to be tested, the use of judgment data in linguistics has attracted controversy from the start and continues to do so (e.g. Branigan and Pickering 2017) – in a way that the analogous use of judgment data in vision science does not.

After first looking more closely at what judgment data are and how they are supposed to provide evidence for linguistic hypotheses, we shall examine these objections, including recent attempts to address some of them experimentally. The research canvassed is part of a movement in recent decades to gather and analyze judgment data more formally than had been typical. We close by surveying some of the new paths this work has opened up.

35.2 What They Are

Judgment data are meta-linguistic judgments – judgments about specific linguistic items, construed broadly to include language-*like* items (e.g. ungrammatical strings). Linguists advert to a wide variety of meta-linguistic judgments. We have already mentioned judgments about acceptability, co-reference, ambiguity, and pronounceability, but there are plenty more: judgments about truth-value, entailment, frequency of use, etc. Moreover, within these types, the judgments may be expressed in a variety of ways. As explained below, subjects may be asked to rate a sentence's acceptability on a Likert scale, for example, or to provide a magnitude estimation, or to express preferability by performing a forced choice among multiple sentences.

But not *all* meta-linguistic judgments are used as evidence: that "I wonder what who saw" (but not "I wonder who saw what") violates the superiority condition is a meta-linguistic judgment, but one invoked in linguistic theorizing to explain data, not as a datum itself. Other cases can be less obvious – notably, judgments of (un)grammaticality. It was once common for linguists to advert to such judgments as evidence, but now they do so far less frequently. This in part reflects the use of "grammar" as a technical term for I-language, so that a "judgment about grammaticality" in that sense refers to a proposed explanation of evidence (cf. Chomsky 1965, p. 11, on acceptability vs. grammaticality). When linguists serve as their own subjects, there is a particular risk of not clearly distinguishing *explanans* and *explanandum*.

What then distinguishes meta-linguistic judgments of the kind used as evidence? In fact, it is not clear that there is an informative general answer that captures all and only the relevant cases. But canvassing some candidates nonetheless helps bring out some central, typical features.

One answer is that such judgments are in some sense intuitive; and indeed the judgments used as evidence are sometimes referred to as linguistic intuitions. Some linguists eschew this label, perhaps owing to unwanted suggestions not encouraged by the more neutral term "judgment data" – for example, that subjects have a special intuitive faculty that provides them access to the causes of their judgment (in particular, their I-language), or that hunches about the causes of judgment may serve as useful data. Another reason could be that it is none too easy to spell out the intended sense of "intuitive" in a way that captures the judgment data that linguists in fact use. For example, linguistic intuitions are sometimes characterized as relatively immediate, or unreflective, or not based on conscious inference. But it can take time and effort to get a reading of a sentence, and reflection and perhaps conscious inference to arrive at a truth-judgment; experimenters may find it informative to compare rushed and considered judgments; and, even if a linguist developed the skill to spot and label, for example, Superiority violations quickly and without reflection, it is not obvious that would increase the evidentiary value of the resulting judgments. Still, the characteristic features of "intuitive" judgments hold of a large range of judgment data, and their doing so helps explain their usefulness. For a relatively immediate, unreflective judgment not based on reasons is more likely to reflect the character of I-language – the object of inquiry – rather than the subject's beliefs *about* language or other intrusions from higher cognition.

Judgment data are also often characterized as introspective (sometimes critically, as we will see). But again, it is not clear that this applies to all the judgments linguists use as evidence. The question turns in part on what is meant by "introspection." On one common characterization, introspective judgments are noninferential, nonexteroceptively based judgments about one's own mental states (Schwitzgebel 2019). Some judgment data may be introspective in this sense, as when subjects report whether a sentence sounds good. But a judgment that a sentence is acceptable, or an utterance true, is about the sentence or the utterance, not about one's mental states concerning them. (Compare: If I report that it is raining, the report *expresses* my belief, but both the report and my belief are about the rain, not about my belief itself, nor about my perception of the rain.) Talk of introspection may be cashed out in other ways – for example, rather than requiring a distinctive kind of internally directed content, one might require just a distinctive kind of access. But it is not obvious how to do so without either collapsing the distinction between perceptual and introspective judgments or omitting some of the judgments linguists use as evidence. An example of the former would be a liberal conception of introspection that included any judgment immediately based on a conscious experience. An example of the latter would be a conception that emphasizes the need to compare similarities and differences across mental states (Chirimuuta 2014), which would render forced-choice preferences introspective, but not acceptability judgments.

Both of these answers – in terms of intuition or introspection – involve in part an appeal to the etiology of the meta-linguistic judgments that serve as evidence in linguistics. Might some other etiological approach do the job? A problem is that the different kinds of judgment – concerning, recall, acceptability, pronounceability, truth-value, even frequency or likelihood of use (Labov 1996) – draw on different cognitive capacities. From the perspective of etiology, judgment data thus appear to form something of a motley. To be sure, in all cases, it is assumed that the etiology involves aspects of our linguistic competence. This assumption is built into the logic of linguists' explanations, when they infer properties of this competence from such causal effects as speakers' judgments. But I-language also figures in the etiology of many judgments *not* used as evidence in linguistics – for example, whenever one comes to believe what one is told. Even if we limit ourselves to just one central kind of judgment – acceptability judgments – it is unclear that we are currently in a position to offer an informative account of their etiology, especially of that part of the causal story that follows upon (attempts at) parsing and comprehension. One natural suggestion is that the presence or absence of error signals of the sort hypothesized by theories of language monitoring may play a role as well in the generation of at least some meta-linguistic judgments (Matthews, unpublished; Sprouse 2018; Gross 2020). But this idea stands in need of development and empirical investigation. Moreover, it is probably not the full story: it is plausible that (in)comprehension also plays a role, as may feelings of effort or disfluency and other factors.

It is useful here to pause briefly over two accounts of how meta-linguistic judgments fulfill their evidential function that provide *alternatives* to the dominant mentalist conception championed by Chomsky. These views have played a significant role in philosophical debates and illustrate how differing conceptions of judgment data and their evidential status are tied to differing conceptions of language and linguistics. But they also illustrate, more specifically, differing conceptions of judgment data's etiology.

According to Katz (1981), languages are abstract objects – akin to mathematical structures – with which we do not causally interact. The meta-linguistic judgments

deployed in linguistics are thus not arrived at via perception or introspection, which would require causal interaction with instances of their object. Rather, we possess a faculty of intuition – the competence-grammar – that provides *a priori* access to these abstract, nonmental structures, including to their necessary properties. This access consists in our capacity to construct *representations* of sentences and their properties from tacit knowledge (innate and learned) of the grammatical principles of the language. The content of linguistic intuitions – for example, that some sentence S is grammatical – is thus directly supplied to judgment by this faculty. Note the contrast with Chomsky's view, as I have presented it, which in no way assumes that I-language itself issues meta-linguistic contents concerning grammaticality – or acceptability, for that matter.[1]

Devitt (2006), on the other hand, endorses a non-Platonist E-language conception of the object of linguistics. On his view, linguistics concerns the possible tokens of a language – not the psychology of speakers – with the tokens' linguistic properties determined by conventions among speakers. These conventions do impose constraints on the psychology of a speaker if she is to count as a competent member of the linguistic community: she must process language in a way that yields outputs whose properties *respect* these conventions. But Devitt denies that satisfying this constraint requires or involves an I-language or modularized language faculty. Thus, *contra* Katz, the contents of judgment data, according to Devitt, are not the direct product of a language module that serves as a faculty of linguistic intuition. Nor do they provide the basis for an inference to the best explanation concerning the properties of I-language. They reflect, rather, the "central systems" knowledge that language-users have of a language after many years of immersion in it – just as regular interaction can lead to fairly reliable knowledge of surrounding flora and fauna.

Critical discussion of these alternative conceptions of language is beyond our scope (but see, for example, Iten, Stainton, and Wearing 2006 on Katz; and Maynes and Gross 2013 and Rey 2020 on Devitt). Our point was to contrast them with the mentalist conception and thus indicate the range of views concerning the etiology of judgment data. It is not in general a condition on evidential status in the sciences that theorists possess a *complete* understanding of the etiology of data (Bogen and Woodward 1988). But further insight into the etiological details – in addition to its intrinsic interest and consequences for other debates in the philosophy of linguistics – could help address some of the worries about the use of judgment data in linguistics to which we now turn.

35.3 Objections to Judgment Data

We remarked that the use of judgment data has never been without critics. The objections have taken various forms. Earlier objections tended to deem judgments problematic as evidence *per se*, not just in linguistics but more generally. Later objections contend that the use of judgment data is problematic more specifically in the linguistic domain, in some cases on account of how they are in fact typically gathered or because of an over-reliance on them over other sources of evidence. No matter their scope, we limit ourselves to objections that target features of putative evidence that would be problematic no matter the type of scientific inquiry. These include failures of validity, reliability, sensitivity, or freedom from bias.[2] We thus set aside worries that judgment data are, say, unscientific or subjective – *unless* cashed in these other terms. This accords with Chomsky's long-standing protests against a "methodological dualism" that would

hold the sciences of the mind to different standards regarding evidence, often based on extra-scientific *a priori* philosophical concerns (e.g. Chomsky 2000, p. 142).

As noted in Section 35.1, a main source of concern for linguists prior to Chomsky stemmed from problems encountered by introspectionist psychology. Introspection proved inadequate to ground a consensus on various of the main questions introspectionist psychology pursued – such as identifying the atoms of sensory experience and determining whether there is imageless thought (see Hatfield 2005). These failures led to a more general mistrust of introspection as a valid or reliable source of evidence – at least for settling illuminating questions (cf. Feest 2014). But was this generalization an instance of salutary methodological caution or an overgeneralization? Introspection may well have been unfit for the purposes to which it was put. The atoms of sensory experience – if there are such – may be too fine for introspection to uncover; and the introspective techniques deployed in the imageless thought controversy tended to target mental processes (about which it is widely agreed that we lack reliable introspective access) rather than their products. It hardly follows that introspective data in general are methodologically suspect – let alone that judgment data are. (Recall from Section 35.2 that judgment data form a broader class than introspective judgments on some common uses of the term *introspection*.) Note, in particular, that the use of judgment data in linguistics is rather different from their use in the introspectionist examples just mentioned: the judgments in linguistics are not themselves *about* mental processes, nor are they used to illuminate sensory experience. Rather, they are products of a mental process aspects of which the theorist attempts to *infer* from those products.

The attempt to generalize beyond introspectionist psychology is further blunted by a comparison with the use of judgment data in contemporary vision science. As with much judgment data in linguistics, the judgments used in vision science may be based on conscious experience and may even ascribe mind-dependent properties, while yet being about external objects and their features, as opposed to subjects' experience. (Though, to be sure, judgments about how things look or appear also play a role in vision science – for example, in work on color constancy.) Because such judgments are based on experience, one may reasonably infer something about the subject's experience from them. But the research question driving a vision scientist need not concern conscious experience. As with the linguist, the vision scientist's concern may be earlier aspects of the judgment's etiology – for instance, aspects of early visual processing. Importantly, in vision science there are no general methodological qualms about using such judgments as evidence. The tremendous success of vision science provides a powerful reply to any general suspicion of judgment data (and, to the extent it relies on judgments that *are* deemed introspective, to any general suspicion of introspection).

This leaves open the possibility that judgment data are invalid or unreliable in particular domains or in particular deployments, as they proved to be in some introspectionist psychology. Language differs from vision in various ways, for example in the degree and kind of individual variation and in the mechanisms by which processing provides material for judgments. Generalizing from success in one domain to success in another requires caution just as generalizing from failure in one domain to failure in another does. The obvious response is that the tremendous success of linguistics based on judgment data likewise makes a strong case for their appropriateness in this domain.

Presenting this case in detail – that is, reviewing significant tracts of linguistics – is, of course, beyond our scope, but also perhaps not to the point, at least so far as more recent critics are concerned. For they are familiar with this work and yet their worries

persist. Instead, we can consider how such a case could be strengthened in response to two more specific objections sometimes raised about the use of judgment data in linguistics. The first is that the validity and reliability of this data is threatened by the "informal" way the judgments are typically gathered in practice. Much judgment data consists in linguists reporting their own responses. It is objected that data collected in this manner are subject to confirmation bias, not properly controlled, and not amenable to statistical analysis owing to the small number of subjects (often just one!). Second, critics sometimes bemoan the disconnect between work in, for example, theoretical syntax and work in psycholinguistics and other area of cognitive science (Ferreira 2005). The case for judgment data in linguistics would be strengthened to the degree that other converging sources of evidence helped demonstrate that judgment data are in effect sufficiently "calibrated" to the phenomena they are used to understand. Let's consider each of these challenges in turn.

One strategy in response to worries concerning how judgment data are in practice collected is to note that the informal process of gathering judgment data actually involves more than this objection allows (Phillips 2009). Data that make it to print typically receive corroboration by seminar attendees, conference audiences, journal referees, and others – some of whom may be biased toward other hypotheses. As for controls, linguists often look for "minimal pairs": strings that differ so far as possible only in one way relevant to the hypothesis in question ("John is eager to please" vs. "John is easy to please"). Even when only a single string is presented in a published text, many variants may also have been considered – and expert consumers of the publication will consider many variants as well in reflecting on what they read. Indeed, "informal" methods allow for the consideration of many more variants than do more "formal" methods involving many subjects. Finally, strong linguistic judgment data share a feature with the judgment reports used in vision science: readers are often in a position to readily judge for themselves. For example, in a highly cited paper on visual adaptation to numerosity, Burr and Ross (2008) reported the judgments of four subjects, two of whom were the authors. While there has been debate concerning the interpretation of their results, no one has challenged the data; for anyone can view the figures and experience the results for themselves. Similarly, in linguistics, judgment data are unlikely to be taken up further in the literature if readers find the judgments dubious.

There is, however, another way one can respond to worries about how judgment data are in-practice collected – namely, by changing how one collects data. Indeed, the last few decades have witnessed a significant growth in "formally" collected judgment data – judgment data gathered from large numbers of naïve subjects using methods common across the social sciences. Work in experimental syntax was catalyzed in part by the publication of Schütze (1996) and Cowart (1997), which laid out, and showed how to avoid, the more subtle confounds to which judgment data can be subject – for example, order effects, where previously considered stimuli affect subjects' response to subsequent stimuli. (For an example of how order effects can be relevant to judgments that serve as evidence for Government and Binding (GB) theory, see Gordon and Hendrick 1997.) Formal experiments are not themselves immune to methodological pitfalls; no process of gathering data is (cf. Culicover and Jackendoff 2010). Confounds may not be controlled for; undetected bias can infect results; subjects can misunderstand instructions; etc. But anticipating and avoiding such problems to the extent possible is at the core of experimentalists' training; and their standards for reporting results are intended to facilitate the further uncovering of design issues and alternative interpretations.

Not only does the use of formal methods provide a response to worries concerning informally gathered data, it also enables the empirical investigation of data-gathering methods themselves. For example, we noted earlier that subjects may in various ways attribute various properties to strings of words. A subject may express the acceptability of a string by rating it on a Likert scale or by providing a magnitude estimate. In the former case, she may select a natural number from 1 to 5, with 1 indicating complete unacceptability and 5 indicating full acceptability. In the latter case, after a numerical starting point is established with respect to an initial string, further strings are placed on an open-ended numerical scale in accordance with their judged distance in acceptability from the initial string. (More specifically, subjects are instructed to rate the further strings as a multiple or fraction of the initial standard – see Bard, Robinson, and Sorace 1996.) Among other advantages, magnitude estimation allows subjects to introduce as many distinctions among strings as they like. Further investigation, however, has suggested that, unlike with other features such as luminance in vision tasks, subjects are unable to judge ratios of acceptability – perhaps owing to the difficulty of establishing a zero point for full unacceptability (Featherston 2008). Perhaps they complete such tasks by tacitly converting them into a more standard rating task, similar to rating along a Likert scale (Sprouse 2011). A methodological inquiry like this can only be done using a more formal approach.

Of particular interest to us is that formal methods can be used to investigate *in*formal methods and thus provide yet another response to worries concerning them – now by potentially vindicating them, as opposed to supplying an alternative to them. For example, Sprouse and Almeida (2012) took all 469 strings that were provided an acceptability rating in Adger's (2003) syntax textbook and tested them on 440 naïve subjects. Using conservative criteria, they found that 98% of the informal judgments replicated. Similarly, Sprouse, Schütze, and Almeida (2013) used a random sampling of 300 informal acceptability judgments drawn from papers published the previous decade in the journal *Linguistic Inquiry* to test naive subjects on three different judgment tasks. Again, using conservative criteria, they found that 95% of the informal judgments replicated. More generally, comparisons of informally and formally gathered judgment data so far appear to vindicate the former, at least relative to the latter (cf. Culbertson and Gross 2009; Mahowald, Graff, Hartman, and Gibson 2016). It should be noted, though, that the work to date has concentrated on acceptability judgments in English (though cf. Linzen and Oseki 2018, albeit still on acceptability judgments).

In addition to investigating consistency between informally and formally gathered judgments, other relevant features have been explored as well – in particular, sensitivity and bias. Sprouse and Almeida (2017) compared the sensitivity (the probability of detecting an effect) of four different judgment tasks. This speaks to the number of subjects needed to achieve statistical power: recall the worry that informally gathered judgments in practice involve too few subjects. The most sensitive task – forced-choice judgments – reached 80% power on strong effects with just 11 participants. As for the possibility of unconscious confirmation bias, Sprouse (2020) notes that one way such bias might reveal itself would be via sign reversals in a comparison between naïve and expert judgments – that is, cases with a change in direction between the effect reported by the two groups. But in fact the data reported in Sprouse, Schütze, and Almeida (2013) revealed very few such cases (about 1–2%) and thus, little evidence for confirmation bias (cf. also Dabrowska 2010).

We have suggested that there is little intrinsic reason to reject judgment data generally and that specific reasons for worry about *linguistic* judgment data based on how they are in practice collected can be avoided by changing those practices, and in any event they are perhaps no cause for great concern. Let's return now to the issue of calibration and more generally of mesh with other methods and theoretical domains. It is a common complaint that there is an over-reliance among linguists on judgment data – at least in theoretical syntax. This is an objection, specific to the linguistic domain, about how such judgments are *used*, not an objection to such data *per se* or to how they are in practice gathered. The other side of the coin for such overreliance would be a dearth of converging evidence from other sources and, in particular, a lack of calibration of judgment data by other methods. As a consequence, we would be permitted less confidence that our evidence provides an accurate measure of the domain we use it to investigate.

Note that the worry pertains to what evidence linguists in *practice* most rely on. It is not claimed that linguists endorse a *principled* restriction of the data to meta-linguistic judgments. Recall Chomsky's objection to methodological dualism. As we saw, it provides a response to certain methodological strictures *against* judgment data – those based on extra-scientific philosophical concerns. But it also undermines any principled restriction *to* judgment data.

Linguists, of course, do draw on a wide variety of evidence: corpus data, developmental and acquisition work, evidence from congenital and acquired deficits, etc. Some of this data – and success in developing theories exploiting it alongside judgment data – does indeed provide a kind of indirect "calibration" of judgment data. But when it comes to the more fine-grained specifics of an individual language's grammar, more direct calibration is difficult to find. A casebook example of a failure to find such calibration comes from the downfall of the Derivational Theory of Complexity, which unsuccessfully attempted to relate grammatical transformations to response times in production and comprehension (Fodor, Bever, and Garrett 1974). Arguably, however, the source of this failure was incorrect theory, not any problem with the judgments on which it was based (Marantz 2005). More recent reading-time studies provide a more successful example of mesh between judgment data and behavioral data, and more generally between the methods dominant in theoretical syntax and those more typical of psycholinguistics. For example, Stowe (1986) found that whether reading time slows at crucial junctures in sentences with filler-gap dependencies depends on whether an active filler strategy would violate a syntactic island constraint (see Phillips 2006 for an overview of reading-time studies). With the increasing use of other experimental methods and the growing *rapprochement* between theoretical syntax and psycholinguistics, there is the possibility that further sources of specific converging evidence will be uncovered (see Sprouse and Schütze 2020 for a discussion of the relations more generally among judgment data and other data).

35.4 The Future of Judgment Data

Informally gathered judgments have supplied linguists with large amounts of easily obtained data directly relevant to their most pressing questions. A glance at leading linguistics journals suggest that they continue to do so – though see Marantz (2005, p. 438) for some skepticism on this score. Supposing that they do, and given the legitimation so far of informal methods by more formal inquiry, the question arises

whether and when the use of formal methods is called for or might prove fruitful. The formal gathering and analysis of judgment data, after all, is not only subject to its own methodological pitfalls (mentioned above), but is also more time-consuming and costly – though less so than it was, owing to the advent of crowd-sourcing platforms such as Amazon Mechanical Turk. We conclude by briefly remarking on a few possibilities:

- One important use of formal judgment tasks has already been noted: to investigate differences among judgment tasks themselves. We mentioned comparisons between formal and informal methods and between Likert-scale ratings and magnitude estimations. Another example is the investigation of how varying task instructions can affect performance (Cowart 1997).
- Various authors propose using formal methods to investigate strings that are hard to judge or where informal judgments diverge (e.g. Linzen and Oseki 2018), whether to settle the status of the case or to better understand the source of the divergence. For example, formal methods can help reveal when variability at the group level masks interesting clusters among sub-groups (Kush, Lohndal, and Sprouse 2018, 2019).
- It has long been recognized that acceptability is gradient; formal methods have made this especially clear. Some point to these results in advocating gradience in grammars (Sorace and Keller 2005 – cf. Chomsky 1965, p. 11). But more work is required to determine whether gradience in acceptability reflects grammatical gradience or rather arises from other sources. Formal judgment tasks will no doubt play a role.
- Indeed, formal judgment tasks, in tandem with tasks of other sorts, have been used to explore how aspects of processing independent of I-language may affect judgments of acceptability. For example, it has long been assumed that working memory limitations can cause a grammatical sentence to be judged unacceptable, with multiply center-embedded sentences providing the parade case. But efforts to establish further working memory effects (surveyed in Sprouse 2018) have so far failed to yield unequivocal results. On the other hand, there has been more success investigating cases – so-called "grammatical illusions" – where features of processing can cause ungrammatical sentences to be judged acceptable (Wagers, Lau, and Phillips 2009; Wellwood et al. 2018).
- The work on grammatical illusions points to another emerging role for formal judgment data. Judgment tasks have traditionally been deployed in theoretical syntax to understand I-language. But formal judgment tasks are proving useful for understanding questions concerning linguistic processing (Phillips et al. forthcoming). More generally, formal judgment tasks hold out the promise of helping linguists better understand the relation between "competence" and "performance" – in particular, between I-language and the linguistic processing that I-language is variously said to be a "part of," or "embodied in," or an "abstraction from" (cf. Lewis and Phillips 2015).

Judgment data, no matter how collected, have a definite future in linguistics. That other methods now also play a large role is all to the good – and something in part made possible by the advances judgment data allowed. Hitting on this large vein and displaying its riches is among Chomsky's enduring legacies.

Endnotes

1 To be fair, one can find remarks by Chomsky that suggest otherwise, as when he writes that there are mechanisms in the mind that permit deduction-like computations from I-language to specific judgments (Chomsky 1986, p. 270). I am articulating the dominant, considered view, which has emerged more clearly in part owing to these debates.

2 These terms are used in their psychometric senses. Evidence is valid just in case it measures what it is intended to measure; and reliable just in case relevantly similar conditions elicit a similar response. ("Validity" and "reliability" have different technical meanings in philosophy.) Sensitivity concerns the true positive rate. Reliability is necessary for validity, but not sufficient: reliably sinking in water was not a valid test of witchiness.

References

Adger, D. 2003. *Core Syntax: A Minimalist Approach*. Oxford: Oxford University Press.

Bard, E., Robertson, D., and A. Sorace. 1996. Magnitude Estimation of Linguistic Acceptability. *Language* 72: 32–68. DOI:10.2307/416793.

Bogen, J., and J. Woodward. 1988. Saving the phenomena. *The Philosophical Review* 97: 303–352.

Branigan, H., and M. Pickering. 2017. An experimental approach to linguistic representation. *Behavioral & Brain Sciences*, 40: e282. DOI:10.1017/S0140525X16002028.

Burr, D., and J. Ross. 2008. A visual sense of number. *Current Biology* 18: 1–4. DOI: 10.1016/j.cub.2008.02.052.

Chiramuuta, M. 2014. Psychophysical methods and the evasion of introspection. *Philosophy of Science* 81: 914-26. DOI: 10.1086/677890.

Chomsky, N. 1955/1975. *The Logical Structure of Linguistic Theory*. Chicago: University of Chicago Press.

Chomsky, N. 1965. *Aspects of the Theory of Syntax*. Cambridge: MIT Press.

Chomsky, N. 1966. *Cartesian Linguistics: A Chapter in the History of Rationalist Thought*. New York: Harper & Row.

Chomsky, N. 1986. *Knowledge of Language: Its Nature, Origin, and Use*. New York: Praeger.

Chomsky, N. 2000. *New Horizons in the Study of Language and Mind*. Cambridge University Press.

Cowart, W. 1997. *Experimental Syntax: Applying Objective Methods to Sentence Judgments*. Thousand Oaks, CA: Sage Publications.

Culbertson, J., and S. Gross. 2009. Are linguists better subjects?" *British Journal for the Philosophy of Science* 60: 721–736. DOI: 10.1093/bjps/axp032.

Culicover, P., and R. Jackendoff. 2010. Quantitative methods alone are not enough: Response to Gibson and Fedorenko. *Trends in Cognitive Sciences* 14: 234–235. DOI: 10.1016/j.tics.2010.03.012.

Dabrowska, E. 2010. Naive v. expert intuitions: An empirical study of acceptability judgments. *The Linguistic Review* 27: 1–23. DOI:10.1515/tlir.2010.001.

Devitt, M. 2006. *Ignorance of Language*. Oxford: Oxford University Press.

Featherston, S. 2008. Thermometer judgments as linguistic evidence. In *Was Ist Linguistische Evidenz?*, edited by C. M. Riehl and A. Rothe, 69–90. Aachen: Shaker Verlag.

Feest, U. 2014. Phenomenal experiences, first-person methods, and the artificiality of experimental data. *Philosophy of Science* 81: 927–939. DOI: 10.1086/677689.

Ferriera, F. 2005. Psycholinguistics, formal grammars, and cognitive science. *The Linguistic Review* 22: 365–380. DOI:10.1515/tlir.2005.22.2-4.365.

Fodor, J., Bever, T., and M. Garrett. 1974. *The Psychology of Language*. New York: McGraw Hill.

Gordon, P., and R. Hendrick. 1997. Intuitive knowledge of linguistic co-reference. *Cognition*, 62: 325–370. DOI:10.1016/S0010-0277(96)00788-3.

Gross, S. 2020. Linguistic intuitions: Error signals and the voice of competence. In *Linguistic Intuitions,* edited by S. Schindler, A. Drożdżowicz, and K. Brøcker. Oxford: Oxford University Press.

Harris, Z. 1951. *Methods in Structural Linguistics*. Chicago: University of Chicago Press.

Hatfield, G. 2005. Introspective evidence in psychology. In *Scientific Evidence: Philosophical Theories and Applications*, edited by P. Achinstein. Baltimore, MD: Johns Hopkins University Press.

Iten, C., Stainton, R., and C. Wearing. 2006. On restricting the evidence base for linguistics. In *Handbook for the Philosophy of Science. Volume 12: Philosophy of Psychology*, edited by Paul Thagard. *Amsterdam: Elsevier.* DOI:10.1016/B978-044451540-7/50024-4.

Katz, J. 1981. *Language and Other Abstract Objects*. Totowa, NJ: Rowman & Littlefield.

Kush, D., Lohndal, T., and J. Sprouse. 2018. Investigating variation in island effects: A case study of Norwegian *wh*-extraction. *Natural Language and Linguistic Theory* 36: 743–779. DOI:10.1007%2Fs11049-017-9390-z.

Kush, D., Lohndal, T., and J. Sprouse. 2019. On the island sensitivity of topicalization in Norwegian: An experimental investigation. *Language* 95: 393–420. DOI:10.1353/lan.0.0237.

Labov, W. 1996. When intuitions fail. *Chicago Linguistics Society: Papers from the Parasession on Theory and Data in Linguistics* 32: 76–106.

Lewis, S., and C. Phillips. 2015. Aligning grammatical theories and language processing models. *Journal of Psycholinguistic Research*, 44: 27–46. DOI:10.1007/s10936-014-9329-z.

Linzen, T., and Y. Oseki. 2018. The reliability of acceptability judgments across languages. *Glossa* 3: 1–25. DOI: 10.5334/gjgl.528.

Mahowald, K., Graff, P., Hartman, J., and E. Gibson. 2016. SNAP judgments: A Small N Acceptability Paradigm (SNAP) for linguistic acceptability judgments. *Language* 92: 619–635. DOI: 10.1353/lan.2016.0052.

Marantz, A. 2005. Generative linguistics within the cognitive neuroscience of language. *The Linguistic Review*, 22: 429-45. DOI:10.1515/tlir.2005.22.2-4.429.

Matthews, R. unpublished. *Linguistic intuition: An exercise of linguistic competence.*

Maynes, J., and S. Gross. 2013. Linguistic intuitions. *Philosophy Compass* 8: 714–730. DOI:10.1111/phc3.12052.

Phillips, C. 2006. The real-time status of island phenomena. *Language* 82: 795–823. DOI:10.1353/lan.2006.0217.

Phillips, C. 2009. Should We Impeach Armchair Linguistics? In *Japanese/Korean Linguistics*, 17. Edited by S. Iwasaki, 49–65. Palo Alto, CA: CSLI Publications.

Phillips, C., Gaston, P., Huang, N., and H. Muller. forthcoming. Theories all the way down: Remarks on "theoretical" and "experimental" linguistics. In *Cambridge Handbook of Experimental Syntax*, edited by G. *Goodall.*

Rey, G. 2020. *Representation of Language: Philosophical Issues in a Chomskyan Linguistics*. Oxford: Oxford University Press.

Schütze, C. 1996. *The Empirical Base of Linguistics: Grammaticality Judgments and Linguistic Methodology*. Chicago: University of Chicago Press.

Schwitzgebel, E. 2019. Introspection. In *The Stanford Encyclopedia of Philosophy*, edited by E. Zalta. URL = <https://plato.stanford.edu/archives/win2019/entries/introspection/>.

Sorace, A., and F. Keller. 2005. Gradience in linguistic data. *Lingua* 115: 1497–1524. DOI:10.1016/j.lingua.2004.07.002.

Sprouse, J. 2018. Acceptability judgments and grammaticality, prospects and challenges. In *Syntactic Structures after 60 Years: The Impact of the Chomskyan Revolution in Linguistics*, edited by N. Hornstein, C. Yang, and P. Patel-Grosz. Berlin: Mouton de Gruyter.

Sprouse, J. 2020. A user's view of the validity of acceptability judgments as evidence for syntactic theories. In *Linguistic Intuitions,* edited by S. Schindler, A. Drożdżowicz, and K. Brøcker. Oxford: Oxford University Press.

Sprouse, J., and D. Almeida. 2012. Assessing the reliability of textbook data in syntax: Adger's *Core Syntax*. *Journal of Linguistics* 48: 609–652. DOI:10.1017/S0022226712000011.

Sprouse, J., Schütze, C., and D. Almeida. 2013. A Comparison of Informal and Formal Acceptability Judgments using a random sample from *Linguistic Inquiry* 2001–2010. *Lingua*, 134: 219-248. DOI:10.1016/j.lingua.2013.07.002.

Sprouse, J., and C. Schütze. 2020. Grammar and the use of data. In *The Oxford Handbook of English Grammar*, edited by B. Aarts, J. Bowie, and G. Popova, 40–58. Oxford: Oxford University Press. DOI:10.1093/oxfordhb/9780198755104.013.28.

Stowe, L. 1986. Parsing WH-constructions: Evidence for on-line gap location. *Language and Cognitive Processes* 1: 227–245. DOI:10.1080/01690968608407062.

Wagers, M., E. Lau, and C. Phillips. 2009. Agreement attraction in comprehension: representations and processes. *Journal of Memory and Language* 6: 206–237. DOI:10.1016/j.jml.2009.04.002.

Wellwood, A., Pancheva, R., Hacquard, V., and C. Phillips. 2018. The anatomy of a comparative illusion. *Journal of Semantics*, 35: 543–583. DOI:10.1093/jos/ffy014.

36

Chomsky's Problem/Mystery Distinction

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36.1 Introduction

Chomsky often appeals to the distinction between problems and mysteries (the p/m distinction). Roughly, the former are topics or phenomena that fall under the scope of our capacity for comprehension or explanation, whereas the latter are topics or phenomena that fall outside of such a scope. Allied to the distinction is Chomsky's hypothesis of a science-forming faculty (SFF), which defines the scope of what we might think of as a possible science. So, whatever falls under the SFF is a problem, and whatever doesn't is a mystery, assuming that the phenomena here are genuine (the nature of absolute time is neither a problem nor a mystery).

The chapter will explain and evaluate Chomsky's remarks on these topics scattered throughout numerous texts. I shall not be concerned with specific claims that this or that phenomenon is a mystery, such as McGinn's (1991, 1993) claims about consciousness, although I shall briefly discuss the topic of linguistic creativity. In short, my focus is on the distinction itself, not what might fall under it.

36.2 What Mysteries Are Not

Before beginning in earnest, it is well to clarify the p/m distinction, whose resonances are liable to mislead.

First, the distinction is a modal one, concerning the *potential* or *possibility* of understanding, not the contingency of what humans happen to understand given the fate of the species or the twists and turns of human intellectual flourishing. For example, if a nuclear holocaust wipes us out tomorrow, we shall not have understood the nature of dark matter, but that doesn't make it a mystery, for we *might* have understood it in more fortunate circumstances. Another sort of contingency is more fundamental. We might never fully understand the evolutionary origins of cognition, not because the relevant explanatory concepts elude us – for all we know, some or other current theory

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might be true –, but simply through a lack of evidence. The cognition of our ancestors leaves some striking evidence, but it is highly partial (Lewontin 1998; cf., Berwick and Chomsky 2016, pp. 97–98). Similarly, we might never be able to understand the origins of the universe for lack of the ability to recreate the energies that would establish some symmetry-breaking hypothesis. Still, some current theory of Plank-scale physics might be true. Again, these kinds of "mysteries" are not under our purview.

Second, the p/m distinction pertains to human cognition, not the world out there independent of us. As Chomsky (2003, pp. 220) avers:

> [W]hen we say human behavior might be beyond our inquiry, that is possible – but [not because] of a "spiritual" property we have: the same thing might be true of large parts of nature.

In short, *x* being a mystery/problem is a relational property indexed to some cognitive system, not an intrinsic property of *x* (Chomsky, 2000, p. 83).

Third, the soundness of the p/m distinction, as intimated, does not rely on a demonstration that some phenomena are mysterious. Pinker (1998, p. 562), who endorses the distinction, still suggests that it is "almost perversely unprovable." His point is that since we appear to lack any clear criteria for what is to count as a mystery, we can't say whether there are any. If there is a human SFF, however, then, in principle, "the limits [that fix the p/m distinction] could become topics of empirical inquiry" (Chomsky 2016, p. 104). In effect, such inquiry would remove the mystery from mysteries, without making the mysteries mere problems. Far from being incoherent, such a pass is confronted in the formal sciences, where perfectly well-formed mathematical problems can be shown to be undecidable given otherwise accepted axioms and proof procedures. This is not a mere limitive result, either, of the kind Gödel famously proved, but applies to substantive mathematical claims, such as Cantor's Continuum Hypothesis. Chomsky's suggestion, more or less, is that what we find in the formal sciences might also pertain to the empirical sciences, grounded in advances in psychology. None of this is to say that the p/m distinction does genuinely carve cognition at a joint; the point is merely that it is not incoherent to, as it were, know that we can't know.

In the next section, I shall explain the p/m distinction via Chomsky's analogy of science with language.

36.3 An Analogy with Language

Chomsky's conception of Universal Grammar (UG) has changed over the years, but the basic idea is that UG specifies the class of possible natural languages, where "possible" means acquirable in the typical way under poverty of stimulus. Just how such a specification is best realized has been subject to much variation, but the lead idea has remained constant.

Chomsky (1968, pp. 90–91) observes an analogy between Peirce's notion of abduction and UG:

> [Peirce] held that innate limitations on admissible hypotheses are a precondition for successful theory construction, and that the "guessing instinct" that provides hypotheses makes use of inductive procedures only for "corrective action" … And, he asked, "How

> was it that man was ever led to entertain that true theory? You cannot say it happened by chance […]." A fortiori, the chances are even more overwhelming against the true theory for each language ever having come into the head of every four-year-old child.

Peirce's basic idea is that there are preconditions on successful science insofar as theorists converge on fruitful hypotheses in ways that are radically (inductively) underdetermined by the data. The admissible hypotheses, therefore, must, in some sense, be restricted to true ones, excluding chance. This presents humans as possessing an instinct for truth ("tendencies to think truly").

Peirce's picture is appropriate to language acquisition only insofar as the child does not inductively determine a correct grammar, but selects one as a hypothesis from, in effect, a UG class of admissible hypotheses. The analogy breaks down thereafter, for in the case of language there are no mind-independent phenomena a language is true of against which our "admissible hypotheses" might be judged:

> We might say that each such cognitive system [a class of "admissible hypotheses"] pertains … to a specific domain of potential fact, a kind of mentally constructed world. If there is a domain of actual fact that is not too dissimilar, the cognitive system can be effectively used. The case of language is unusual in that, there being no external standard, the domains of potential and actual fact are identical; X's grammar is what X's mind constructs. (1981, p. 6; cf., Chomsky 1975, pp. 164–166)

In the case of admissible scientific hypotheses in general, where there is a domain of fact, the question of truth does arise, but we have no justification for an instinct for truth. In this respect, Chomsky diverges from Peirce. Thus, language acquisition and science forming are akin in having an innate basis, even though only the latter is answerable to the world, and so may fall short at some phenomena in a way language cannot (a human language cannot be unacquirable). Thus:

> The fact that "admissible hypotheses" are available to [the SFF] accounts for its ability to construct rich and complex explanatory theories. But the same properties of mind that provide admissible hypotheses may well exclude other successful theories as unintelligible to humans … though these theories might be accessible to a differently organized intelligence. (Chomsky 1975, pp. 155–156; cf. Chomsky 1971, p. 49; 1988, pp. 156–159)

Some years later:

> The successful natural sciences … fall within the intersection of the scope of SFF and the nature of the world. … The intersection is a chance product of human nature. Contrary to speculations since Peirce, there is nothing in the theory of evolution, or any other intelligible source, that suggests that it should include answers to serious questions we raise, or even that we should be able to formulate questions properly in areas of puzzlement. (Chomsky 2000, p. 83; cf., 1988, pp. 157–158)

Firstly, as already made clear, since the p/m distinction is relative to a cognitive system, what is a mystery for some systems might be a mere problem for us (see Section 36.2). Second, on Chomsky's conception, the p/m distinction presupposes what we might call a minimal realism in the sense that the world of facts or phenomena is as it is independent of us, but our fixed conceptual resources that SFF makes available are not guaranteed to get the world right or even be apt to support the right questions to ask,

unlike in the case of language. There is a fortunate but partial intersection between mind and world.

In the following section, I shall critically evaluate Chomsky's considerations in favor of this conception of the p/m distinction.

36.4 Inductive Comfort

A common thought is that long-standing failure to make progress on a puzzle signals that it falls outside our capacity for comprehension. Of course, such a history of failure might be necessary for a mystery (at least one that is identifiable), but it is hardly sufficient. Still, a certain inductive comfort is felt in the history of failure. McGinn (1991, p. 7) notes that "longstanding historical failure is suggestive, but scarcely conclusive." Nagel (1995, p. 97) is less cautious: "The various attempts to carry out this apparently impossible task [i.e., explaining consciousness] and the arguments to show that they have failed, make up the history of the philosophy of mind during the past 50 years." Pinker (1998, p. 562) echoes the general thought: "The species' best minds have flung themselves at the puzzles for millennia but have made no progress." Chomsky often appeals to *linguistic creativity*, rather than consciousness, as a potential mystery. Linguistic creativity involves an agent being free to use, in an uncaused manner, an appropriate utterance drawn from an unbounded class (Chomsky 1966). In a phrase, a speaker makes free, infinite use of finite means. It is as if the speaker has harnessed randomness (unpredictable unboundedness) in a meaningful, appropriate manner. As we shall note later, *pace* Chomsky, it is hard to disentangle a phenomenon being a massive interaction effect, like leaves in the wind, from a *real* mystery, where we constitutively lack the right concepts for understanding. Still, free will, as opposed to consciousness, is Chomsky's preferred example of a potential mystery. As Chomsky (2016, p. 94) recently writes:

> [T]he the creative use of language to Cartesian science … was only one illustration of the general problem of will, and choice of appropriate action, which remains as mysterious to us as it was to seventeenth-century scientists, despite sophisticated arguments to the contrary. The problems are hardly even on the scientific agenda.

I shall not here consider the status of consciousness or free will; instead, I shall merely highlight how such inductive reasoning is far more suggestive than compelling.

Russell (1917, p. 85) remarked that "if any philosopher [pre-Cantor/Weiestrass] had been asked for a definition of infinity, he might have produced some unintelligible rigmarole, but he would certainly not have been able to give a definition that had any meaning at all." Russell's judgment might be a tad harsh, but is more or less accurate. Infinity was certainly a candidate for mystery, being an unavoidable concept, but one apparently heir to essential puzzlement and paradox. Late nineteenth-century mathematics thoroughly domesticated the issue, and the development of computability theory showed how unboundedness could be physically realized as a rule system; indeed, it is precisely because of such achievement that Chomsky considers the infinity aspect of linguistic creativity not to be mysterious; it is only the combination of infinity with being uncaused but appropriate that creates the puzzle (Chomsky 1966, pp. 77–78).

It is not clear, therefore, if any conclusion, pro or con, is supported by a history of failure. One may think of many other cases. Cosmology wasn't on the scientific

agenda, being deemed theological, prior to the development of general relativity and its cosmological constant. Life appeared to be the provenance of extra-physical forces or principles prior to the development of post-Darwin evolution and the *new synthesis*. Even the Sun posed imponderable questions pertaining to its fuel source, which conflicted with the evolutionary time-scale; it took the development of nuclear physics to relieve the puzzlement. None of this history suggests a triumphalist unbounded march of science, but it does suggest that the inductive comfort of past failings is an illusion. Some tautologies bear emphasis: we don't know until we know.

36.5 We Are Not Angels

If we look at the rest of the animal kingdom, we find cognitive closure: problems we may solve, but which elude other organisms. A favored example is that of the maze-solving abilities of rats (e.g. Chomsky 1991, p. 41; 1993, p. 45; 2000, p. 107). Over a large range of mazes (e.g. radial ones) rats perform at levels equal to or greater than humans, but some mazes prove intractable. For instance, a prime maze is one whose solution depends on the subject making a certain decision (left or right) at each prime choice. Rats' poor performance with such mazes is naturally explained by their lack of number theory. Of course, it does not follow that the average person would perform much better than a rat, yet the average person has the concepts that would enable him or her easily to solve the maze. Even if one lacked the explicit notion of a prime, one could still work out the maze by "discovering" the concept. This a rat cannot do. Thus:

> [I]f human beings are part of the natural world, not supernatural beings, then human intelligence has its scope and limits, determined by initial design. (Chomsky 2000, p. 107)
> We are biological organisms, not angels … [I]f there were no limits to human intelligence, it would lack internal structure and would therefore lack scope: we could achieve nothing by inquiry. (Chomsky 2016, pp. 104–105)

Chomsky's point here, note, is not merely that, like other animals, we have cognitive limits, even if unknown to us, but perhaps identifiable by aliens or actual inquiry into our SFF (Chomsky, 2000, 83). The more fundamental point is that the very system that gives us the scope to tackle problems will impose limits (cf., Fodor 1983, pp. 124–125). This follows because a cognitive system cannot be a general unspecified system of thought, but must have a specific design and intrinsic conceptual capacities in order to operate on the buzzing, irregular confusion of the external world. Chomsky's thought here is that the very systems that allow us to specify regularity and underlying structure in our world impose limits precisely through their possessing a specific design independent of the variances of our experience. Absent such endogenous invariances, we should merely reflect the chaos of experience, and be unable to abstract to concepts that impose invariance on experience and so allow for the identification of phenomena, not just experience. Again, the analogy with language is useful. Were we tasked with inferring syntactic structure from experience, the problem would be a mystery, for the required principles of hierarchical organization, covert movement, and many phonologically null elements could not be determined. UG makes the task relatively straightforward by relieving us of an impossibly heavy evidential burden. Simultaneously, it imposes strict limits on what is to count as a language, i.e., one answering to the very principles and concepts employed to learn any language.

Dennett (1993, p. 382) has objected to this line of reasoning, suggesting that it is precisely language that distinguishes us from the rest of the animal kingdom. Dennett has two arguments. First, since language allows for denumerably many sentences, we have a guarantee at least to be able to formulate any true theory, which would just be some selection from the infinite class of sentences Second, language allows for culture, where we can pool our cognitive resources. In effect, language allows us to be Lamarckian in our intellectual evolution: we can learn from the past, free of the burden of learning everything anew. Both arguments miss their target.

On the first point, that our linguistic competence is unbounded does not entail that it allows for the formulation of every true theory. Trivially, a language can be unbounded, such as sentential logic, while still being expressively weaker than some other unbounded language, such as first-order logic, second-order logic, etc. More prosaically, Chomsky's position does not entail that every true theory has a potential linguistic representation. The language faculty fixes grammatical structure, not the concepts that may be lexically expressed. In other words, sometimes we need to invent a bit of conceptual kit above and beyond natural language. The proper development of the calculus, for example, involved the definition of limits as the values of (infinite) partial sums. It is unclear how limits so understood, and the attendant formalization of continuous function, can be explicitly linguistically expressed. We can partially describe the mathematics in English but not do it in English, which does not contain infinitely long sentences. Similarly, we can entertain *n*-order quantification, but it is unclear if natural language even allows second-order quantification.

On the second point, while it is true that language makes our intellectual evolution as if Lamarckian, it doesn't follow that the evolution lacks any cognitive closure. Suppose the rats could talk to each other about mazes and reflect on their history, and learn heuristics, etc.; they would still fail at prime mazes, if they couldn't formulate the concept of prime number, which, *ex hypothesi*, they lack. It is unclear how culture could issue in the right concepts unless they are latent in the first place.

Suppose, then, that Chomsky's general reasoning is correct, that human cognitive design imposes both scope and limits on the kind of theoretical inquiry we may fruitfully pursue. This conclusion does not so much validate the SFF hypothesis, and so ground the p/m distinction as a fortunate intersection of world and admissible hypotheses, as refute an empiricist conception of there being a lack of relevant cognitive design. That is, even if we grant that each cognitive system has an essential design that defines both the scope and limits of the system, the possibilities of future science appear to be radically underdetermined, for we remain in want of a conceptual specification of what counts as a possible science that issues from our native cognition. This point concerning how mere closure fails to specify any particular conceptual limits is sometimes obscured, I think, by another distinction Chomsky makes, which is actually orthogonal to the p/m distinction, but is employed to the same rhetorical ends.

Chomsky (2002, pp. 51–52; 2016, pp. 90–91) draws a distinction between the endeavor to find the world intelligible and the construction of merely intelligible theories. The thought is that, according to post-Galileo modern science: "when mechanism fails, understanding fails." In this respect, the world becomes unintelligible, alien to our native "mechanistic" conceptions of matter and its interactions; in its stead we must be content with "intelligible theories," which meet internal standards of simplicity, consistency, and deductive depth, and capture selective desperate phenomena, but which are untethered from any folk physics or natural ways of conceiving of the world.

I don't here want to assess these claims, but only to register them. Chomsky goes further, however.

Chomsky avers that Newton destroyed the machine of the body while leaving the ghost of the mind untouched, meaning that there is no primitive materialist metaphysics from whose vantage point the mind might be deemed other. "Lacking a concept of 'matter' or 'body' or 'the physical,' we have no coherent way of formulating issues related to the 'mind-body problem'" (Chomsky 2000, p. 110; cf., 1996, pp. 40–43). The point that bears emphasis in all of this is that the retreat from finding the world intelligible to discovering merely intelligible theories is orthogonal to the p/distinction, even if "understanding fails" when we are obliged to make the retreat, as Chomsky suggests is characteristic of modern science.

Suppose we have a faculty of commonsensical or folk physics (Baillargeon 1994; Spelke 2000). Chomsky may be modestly read as correctly noting that modern science takes us beyond its scope, where theories are no longer answerable to intuition or common sense but instead establish their own standards of correctness and intelligibility, often mathematically expressed. This departure does not betoken mystery, however, or a fundamental failure of understanding; it indicates, rather, that a different faculty of mind (the SFF) gives scope and limits to inquiry beyond common sense.

The same problem concerning the specification of conceptual limits now returns, for we still don't know what the content of the SFF is, if it is not folk physics, about which much profitable work has been undertaken. Indeed, if "the physical" becomes a cypher for whatever the physicists say, then a specification of the SFF would be approximate to dictating the possible future shape of physics, an achievement supposedly beyond us that renders the mind-body problem incoherent. It is not adequate to respond to this worry that we might discover the SFF's content through looking at the history of science and studying the mind itself (Chomsky, 2000, 104). That possibility is not to be a priori doubted, but the real problem here is that we have no reason to think that science forming, and so the p/m distinction, is grounded in anything purely cognitive, a faculty, along the same lines as, indeed, language or folk physics. Independent of the particular content of these faculties, we have good reason to think that they are cognitively grounded due to their particular developmental profile. No such independent basis is available for science forming. If there were some such basis, then the content of SFF would be a promising research agenda, but that is not the state of play. Chomsky (1980, p. 140) notes this:

> The basic elements of rational inquiry may have some of the properties of such cognitive systems as the language faculty, though the ways they are employed are surely quite different: scientific knowledge does not grow in the mind of someone placed in an environment.

In other words, science forming is developmentally unlike language, or folk physics, for that matter; indeed, science has no developmental profile. So, if we can't conceptually specify the SFF and science forming lacks any developmental profile, why think there is a SFF? Perforce, why think the p/m distinction can be cognitively grounded?

Cary and Spelke (1994) distinguish science from natively developed knowledge, for the former is not restricted to, nor directly constrained by, the domain-specific "core" knowledge that may reasonably be thought of as innate. They picture science proper as enabled by analogical mappings across the innate domains, the result being "constructed" knowledge. Chomsky appears not to endorse any such model, but depicts the SFF as a separate capacity from "core knowledge," not an interactional effect of distinct

systems. Besides, the notion of analogical mapping is so loose as not to offer the kind of differentiation entailed by the p/m distinction.

The basic problem, therefore, is that we have no independent reason from developmental psychology to think that there is an SFF, and it is unclear what its content might be, unlike the case of folk physics. This pass does not refute the p/m distinction or its basis in a putative SFF. The conclusion, rather, is that the p/m distinction is coherent as a result of general anti-empiricist reasoning, but the SFF hypothesis as an independent explanation of the distinction remains speculative with no clear correlates for the putative faculty, either in terms of development or content.

36.6 Convergence

A further suggestion from Chomsky is that convergence is a key signature of a SFF. Chomsky (1975, pp. 24–25; cf., 1971, pp. 49–50) has contended that without a SFF

> it would be *impossible* for scientists to converge in their judgement on particular explanatory theories that go far beyond the evidence at hand, … while at the same time rejecting much evidence as irrelevant or beside the point, for the moment at least [my emphasis]

One way of reading this claim is via a thought experiment. Imagine a random group of suitably intelligent people. Give them the accumulated knowledge pertaining to some domain up to time t. Will they independently converge on a new theory? A positive answer strikes me as wildly implausible, and is historically suspect (see Holton 1973/88, for excellent discussion of the development of special relativity; in particular, the fact that Lorentz and Poincare – no slouches – were appraised of all the material that led to Einstein's unique insight). Discovering physical theories is not like acquiring the grammar of the ambient language.

There is, however, a far more plausible idea behind Chomsky's remarks. *Ex post facto* convergence is what indicates an SFF. Convergence on scientific theories requires explanation, for that there is convergence at all appears not to follow from the observational data, still less the socio-cultural facts of scientific practice. We appear to have shared standards of scientific elegance and depth, which do not entail that we are all capable of the same theoretical insights, but which do allow us to recognize insight once presented. The important point, which makes for Chomsky's fortunate intersection of mind and world, is that our principles concerning what is to count as a correct theoretical framework are shared by us and meet with some success, but are neither entailed by the data nor appear to be a logical necessity.

If we grant so much, then we cannot recover a clean p/m distinction; one that would allow us to *decide* what phenomena are mysterious due to a specified range of concepts failing to apply to them. We may, instead, be able to discern a certain shape to theoretical inquiry, informed by a cognitive design that privileges symmetry, elegance, depth, etc., which might foreclose many avenues of inquiry simply because the relevant phenomena are too complex to submit to such explanation, not because they are unintelligible or beyond our concepts. Chomsky (2003, p. 219) reflects that

> we may know the laws, but the possibility of applying them, or of solving the equations, or of working out the problems, or of understanding what's going on, declines very fast when we get past only the very simplest things.

In this light, linguistic creativity might count as a mystery in one sense, not because an SFF specifically excludes a true theory of it but because it is such a complex interaction of principles and contingent factors. It appears as if a uniform phenomenon because our language use is not mere randomness or noise thanks to it being "appropriate" to an agent's goals and intentions: a speaker appears to harness unpredictable randomness, as I put it above. Still, such apparent univocity might hide mere complexity rather than betoken a fundamental yet out-of-reach explanatory concept that, were we to possess it, would render the correct theory intelligible to us. A more general thought in this direction is offered by Weinberg's discussion of the prospects of a "final physical theory." Weinberg (1993, pp. 191–193) highlights that the achievement of such a goal would not bring an end to science, but only terminate a *kind* of science, stretching back to Galileo, where a fundamental set of equations are sought, which don't require any more basic explanation: they would be uniquely simple and predictive of the phenomena. Suppose that the relevant sense of finality here is fixed by human cognition, perhaps via mathematics, in the form of a conception of perfection or rigidity. What falls outside of this scope would lack an ultimately satisfying explanation, for it would depend on further principles in ways that might forever remain obscure, or be the result of a massive interaction effect between contingent factors and general principles, in ways Chomsky describes as quoted just above. In this light, to think of free will, say, as a mystery amounts to no more than the phenomena of choice not being subject to the *kind* of theory we should deem ultimately satisfactory. The phenomenon itself is non-spooky, and a differently "organized intelligence" might approach the problem in an entirely different way. In this somewhat etiolated sense, mysteries are just those phenomena that fall outside of physics in a suitably general sense, not because we can't formulate the right concepts, but because they are too complex and multifaceted for the kind of theories we deem to be explanatory.

36.7 Conclusion

Although I have been critical of Chomsky's framing of the p/m distinction and the attendant notion of an SFF, I do not suggest that the idea is confused. To the contrary, science is only possible given the kind of minds we possess, which impose both scope and limits to inquiry. It doesn't follow that we could be in a position to extrapolate from this general thesis to the conclusion that specific phenomena are mysterious because they fall outside of an SFF. Such an inference requires a specification of some content to the SFF, but it is currently unclear what it might be, if it goes beyond folk theories or general desiderata of depth, elegance, simplicity, etc., which leave the scope of possible science radically underdetermined. Still, the science there is and will be reflects the kind of creatures we are, and so reflects basic principles of explanation and theoretical virtue, which issue from us, not from the world itself. Where we are inclined to look and what we find satisfying is a matter for us, which includes a rich terrain, but casts in darkness a potentially richer terrain, albeit one too complex for explanation. As Chomsky's version of the '"streetlight effect" has it, the drunk looks for his keys under the streetlight, not because that is where the keys are, but because that is where the light is (Barsky 1997, p. 95).

References

Baillargeon, Renée. 1994. How do infants learn about the physical world? *Current Directions in Psychological Science* 3: 133–140.

Barsky, Robert. 1997. *Noam Chomsky: A Life of Dissent*. Cambridge: MIT Press.

Berwick, Robert, and Noam Chomsky. 2016. *Why Only Us: Language and Evolution*. Cambridge: MIT Press.

Carey, Susan, and Spelke, Elizabeth. 1994. Domain-Specific Knowledge and Conceptual Change. In *Mapping the Mind: Domain Specificity in Cognition and Culture*, edited by Lawrence Hirschfeld and Susan Gelman, 169–200. Cambridge: Cambridge University Press.

Chomsky, Noam. 1966. *Cartesian Linguistics: A Chapter in the History of Rationalist Thought*. New York: Harper and Row.

Chomsky, Noam. 1968/72. *Language and Mind. Enlarged Edition*. New York: Harcourt Brace Jovanovich

Chomsky, Noam. 1971. *Problems of Knowledge and Freedom: The Russell Lectures*. New York: Vintage.

Chomsky, Noam. 1975. *Reflections on Language*. London: Fontana.

Chomsky, Noam. 1980. *Rules and Representations*. New York: Columbia University Press.

Chomsky, Noam. 1981. On the Representation of Form and Function. *Linguistic Review*: 1, 3–40.

Chomsky, Noam. 1988. *Language and Problems of Knowledge: The Managua Lectures*. Cambridge: MIT Press.

Chomsky, Noam. 1991. Linguistics and Cognitive Science: Problems and Mysteries. In *The Chomskyan Turn*, edited by Asa Kasher, 26–53. Oxford: Blackwell.

Chomsky, Noam. 1993. *Language and Thought*. Wakefield, RI: Moyer Bell.

Chomsky, Noam. 1996. *Powers and Prospects: Reflections on Human Nature and the Social Order*. London: Pluto Press.

Chomsky, Noam. 2000. *New Horizons in the Study of Language and Mind*. Cambridge: Cambridge University Press.

Chomsky, Noam. 2002. *On Nature and Language*. Cambridge: Cambridge University Press.

Chomsky, Noam. 2003. *Understanding Power: The Indispensable Chomsky*. London: Vintage.

Chomsky, Noam. 2016. *What Kind of Creatures are We?* New York: Columbia University Press.

Dennett, Daniel. 1993. *Darwin's Dangerous Idea: Evolution and the Meanings of Life*. London: Penguin.

Fodor, Jerry. 1983. *The Modularity of Mind*. Cambridge: MIT Press.

Holton, Gerald. 1973/*88. Thematic Origins of Scientific Thought: Kepler to Einstein. Revised Edition*. Cambridge, MA: Harvard University Press.

Lewontin, Richard. 1998. The evolution of cognition: Questions we will never answer. In *Methods, Models and Conceptual Issues: An Invitation to Cognitive Science, Volume 4*, edited by Don Scarborough and Saul Sternberg, 107–132. Cambridge: MIT Press.

McGinn, Colin. 1991. *The Problem of Consciousness*. Oxford: Basil Blackwell.

McGinn, Colin. 1993. *Problems in Philosophy: The Limits of Inquiry*. Oxford: Blackwell.

Nagel, Thomas. 1995. *Other Minds*. Oxford: Oxford University Press.

Pinker, Steven. 1998: *How the Mind Works*. London: Penguin.

Russell, Bertrand. 1917. *Mysticism and Logic*. London: Unwin.

Spelke, Elizabeth. 2000. Core knowledge. *American Psychologist*, 55: 1233–1243.

Weinberg, Steven. 1993: *Dreams of a Final Theory: The Search for the Fundamental Laws of Nature*. London: Vintage.

37

Knowledge, Morality, and Hope: The Social Thought of Noam Chomsky

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In his first published essay on politics, Noam Chomsky (1967/69, p. 325) announced his conviction that "[i]t is the responsibility of intellectuals to speak the truth and to expose lies.'[1] Acting on that conviction, Chomsky has long supplemented his work in linguistics with writing on contemporary political affairs, focusing principally on the politics of the Middle East, the immorality of US foreign policy, and the role of American mass media and intellectuals in disguising and rationalizing that policy.[2] By contrast with his work in linguistics, which is principally theoretical, Chomsky's political writings in the main address more straightforwardly factual questions. As he emphasizes, these can be settled without special methods or training, and their significance can be appreciated through the application of commonsense norms and beliefs (for example, that aggression is wrong, concentrated power is dangerous, and citizens have greater responsibility for the policies of their own country than for those of other states), as aided by "a bit of open-mindedness, normal intelligence, and healthy scepticism" (Chomsky 1977, p. 3).

The characteristic focus, intensity and hopefulness of Chomsky's political writings, however, reflect a set of more fundamental views about human nature, justice and social order that are not simple matters of fact. This article explores these more fundamental ideas, the central elements in Chomsky's social thought. We begin (section I) by

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sketching the relevant features of Chomsky's conception of human nature. We then examine his libertarian social ideals (section II) and views on social stability and social evolution (section III), both of which are animated by this conception of our nature.

To anticipate what follows, we take Chomsky's social views to be marked by four key claims: (1) human beings have a "moral nature" and a fundamental interest in autonomy; (2) these basic features of our nature support a libertarian-socialist social ideal; (3) the interest in autonomy and the moral nature of human beings help to explain certain important features of actual social systems, including for example the use of deception and force to sustain unjust conditions, as well as their historical evolution; and (4) these same features of human nature provide reasons for hope that the terms of social order will improve from a moral point of view. Thus stated, these four claims are clearly neither concrete nor precise. But neither are they vacuous. They provide what we take to be a distinctive, optimistic perspective on human beings and human possibilities. The exposition that follows aims principally at a sympathetic clarification of this perspective. While our discussion is often critical, the criticisms themselves are intended to clarify Chomsky's views and to underscore deeper points of agreement with them.

Before turning to that discussion, however, a cautionary remark about the character and self-conception of Chomsky's work in this area is in order. Most important, Chomsky does not have a theory of society or justice, in the sense of a clearly elaborated and defended set of fundamental principles. In fact, he believes that significant progress in ethical and social inquiry requires a systematic theory of human nature, something that does not now (and may never) exist,[3] and that in the absence of such a theory social and ethical thought must rely on relatively speculative and imprecise ideas (guesses, hopes, expectations") (Chomsky 1988a, 756). Moreover, Chomsky denies any originality for his social and ethical views, identifying himself as a merely "derivative fellow traveller" (Chomsky 1981, p. 247) in the anarchist and libertarian-socialist traditions.

Finally, and no doubt in part owing to his conviction that his social and ethical views are neither systematically developed nor original, Chomsky presents those views in an occasional and sketchy fashion. Almost always announced as speculative, and often advanced only in response to promptings from interviewers, their presentation commonly takes the form of quotation from and endorsement of certain views of other thinkers (for example, Rousseau, Kant, Humboldt and Marx) (see Chomsky 1970/81, 1973, 1981). Apart from creating natural difficulties for any attempt at systematic summary, the character of Chomsky's presentation underscores the need for caution in reading more into, or expecting more of, his work in this area than he invites. We hope that we have heeded our own warning in what follows.

37.1 What Can We Know? Rationalism Romanticized

As already noted, Chomsky believes that a substantive conception of human nature must play a central role in both the ethical assessment of social arrangements and in the explanation of their operation. By a "conception of human nature" he means an account of the biological endowment of the human species, and in particular the aspects of that endowment that figure in the development of human cognitive systems – aspects that are common to all human beings (excepting those suffering from pathologies) and perhaps unique to the human species. At its core, Chomsky's own conception of human nature draws together a romantic emphasis on the distinctive

human capacity for creative expression and a rationalist contention that there is an intrinsic and determinate structure to the human mind.[4] In his work, these romantic and rationalist strands are joined through the contention that the intrinsic structure of mind provides a framework of principles that underwrites the possibility of the relevant forms of creative activity, while at the same time limiting the attainable forms of human expression.[5]

This conception of human nature is most fully developed in Chomsky's linguistic theory, which emphasizes both the creativity exhibited by normal human language use and the modularity of the human language faculty.[6] According to Chomsky (1965, 57), the "fundamental fact about the normal use of language" is its "creative aspect'. Human beings have the capacity for a potentially unbounded novelty in the production of utterances that are appropriate to their circumstances, but that are not controlled by immediate stimuli (though they are commonly prompted by such stimuli). The linguistic knowledge expressed in such creativity is acquired by virtually all human beings in a relatively short period of time, and in the face of unstructured and impoverished inputs from the environment. Given this "poverty of the stimulus," Chomsky argues that language acquisition can plausibly be explained only on the assumption that human nature includes a language "module" – an innate system of language-specific principles, or "Universal Grammar."

Chomsky's more general remarks about human nature are fuelled by the speculation that these ideas about creativity and modularity in the domain of language might have more general application, and that the theory of language might suggest a paradigm for a more general account of our nature. Thus he notes that "at some very deep and abstract level some sort of common-core conception of human nature and the human drive for freedom and the right to be free of external coercion and control" of the kind that figures "in a relatively clear and precise way in my work on language and thought" also "animates my social and political concerns" (Chomsky 1988a, pp. 696–697).

37.1.1 Language and Human Nature

To understand how the ideas featured in the linguistic theory might be extended to provide a broader account of human nature, consider first the modularity hypothesis. In areas other than language – for instance, vision, scientific reasoning, aesthetic and moral judgment – human beings might be thought to attain complex and determinate cognitive systems in the face of relatively impoverished data, thus suggesting the presence of modules governing cognitive development in these other domains as well. For example, human beings appear to have a moral nature. That is, there appears to be a natural human tendency to interpret human interaction in moral terms – to display a concern about the justifiability of actions in light of their effects on the well-being of others. That concern is manifest in, among other things, complex systems of moral judgment that are deployed in response both to actual problems and to the hypothetical cases of moral philosophy; furthermore, these systems appear to go well beyond anything that might plausibly be found in the "impoverished and indeterminate" data available to a child who receives moral instruction (Chomsky 1988b, p. 153).

The hypothesis of moral modularity would explain the acquisition of a system of moral understanding in part in terms of a set of intrinsic features of mind that are specific to morality. A characterization of the moral module would of course need to be consistent with the variety of moral systems, but it would also impose limits on

possible human moralities. Thus, features of it might help to explain certain formal properties that are allegedly displayed in systems of moral understanding (for example, why moral conceptions are either deontological or teleological, or why moral norms feature elements of symmetry, generality and impartiality) and/or certain substantive features that seem to be common in moral systems (for example, prohibitions against killing innocents, want only imposing pain, or enslaving members of the community).[7]

Consider next a natural generalization of the creative aspect of language use. Here the thought would be that, by underwriting the acquisition of a variety of complex cognitive systems, our nature enables us to engage in creative activities that deploy those systems. Thus creativity would be a feature not just of language use but of moral judgment, common-sense understanding, and the use of that understanding in productive work, artistic activity and scientific achievement. Of course, a human potential for creativity might be joined with a desire for habit and repetition and a hatred or dread of novelty. But Chomsky's contention is that, associated with the intrinsic possibilities for human creativity and underscoring their relevance for ethics and social explanation, there exists an innate propensity to pursue the forms of creative expression for which our nature suits us. Borrowing a phrase from Bakunin, Chomsky (1988b, p. 155) sometimes refers to this as an "instinct for freedom" Elsewhere he suggests that we have not merely an instinct towards but also a need for such free activity, and that the failure to accommodate that need results in individual and social pathologies (for example, Chomsky 1970/73, p. 405). Taking the remarks about instinct and need together, Chomsky appears to endorse the view, associated with Aristotle, that human beings enjoy the exercise of their natural powers, with enjoyment perhaps scaled in part to the complexity of the activity in which those powers are engaged, and that we enjoy as well the exercise by others of their powers, at least when we have the opportunity to engage in like activities ourselves.[8]

Certain features of this view strike us as significant and plausible. Much historical sociology testifies to the claim that there is a fundamental human interest in free activity (alongside other interests in some level of material comfort and in being treated with respect by others), and that human beings have a moral nature in the sense just described.[9] It is, for example, not implausible to explain the destruction of slavery, the development of religious pluralism, and the evolution of democratic ideals and their (admittedly highly imperfect) expression in social and political arrangements, in part by recourse to these basic features of human beings. It is less clear, however, that these matters are illuminated by considerations of modularity and creativity drawn from the theory of language. It may be the case, for example, that human beings have a moral nature but lack a specifically moral module. What underlies our acquisition of moral systems might instead be, as Kant (1788/1956, Pt I,bk i] supposed, intrinsic features of human reason as such. On this account, the construction of moral systems would not involve the deployment of principles specific to a moral faculty, but rather the application of a "pure reason" to matters of human action. This might be sufficient to account for moral competence – for the complexity and determinateness of human moralities, and the capacity to respond to novel cases in ways that transcend specific instruction – even if the parallel contention about the acquisition of linguistic knowledge is not at all plausible. We do not wish to defend this alternative perspective, but only to stress that the important contention that human beings have a moral nature does not depend for its plausibility on the assumption of a moral module.

Similarly, reflection on the creative aspect of language use does not seem to help in understanding human aspirations to self-directed activity – the fact that "people really want to control their own affairs … [and] don't want to be pushed around, ordered, oppressed, etc." (Chomsky 1988a, p. 756) What is central to linguistic creativity is the capacity for unbounded novelty. But what matters to people in their aspirations to self-direction – to form conceptions of a decent life and to act on those conceptions – appears not to depend on the prospect of novelty of expression. For example, even if one were persuaded that one's artistic, craft or intellectual activities would issue in nothing novel, one's interest in pursuing that activity free of external control, without being "pushed around," would be likely to remain undiminished.

In sum, we agree with Chomsky's claims about our moral nature and "instinct for freedom," but are less persuaded by the suggestions about how these features of human nature might be understood on the model of the theory of language.

37.2 What Ought We to Do?

Chomsky's normative views, and in particular his account of a good society, are set against the background of his conception of human nature, and the conception of an instinct for freedom that lies at its heart. In outline, Chomsky takes freedom to be the supreme human good, and endorses the libertarian principle that the evaluation of social arrangements should proceed by considering whether those arrangements impose tighter limits on human activity than are necessary, given existing material and cultural constraints.[10] This, of course, is not an especially determinate view. Embracing the supreme value of freedom, and endorsing the principle that unnecessary constraints on it should be eliminated, does not settle issues about the appropriate treatment of time trade-offs (for example, the relative importance of freedom for present and future generations) or distributional issues (in particular, whether it is legitimate to trade the freedom of some for the freedom of others). Still, the conception is not empty. According to Chomsky, indeed, it supports a particular ideal for human beings operating under the material and cultural constraints of modern industrial societies – namely, socialist anarchism. The best known of his ethical-political views, Chomsky's anarchism is worth exploring at length.

It may be useful here to distinguish two conceptions of anarchism, each of which figures in Chomsky's work. In the first, anarchism is represented not as a substantive "doctrine" but as a "historical tendency," a "permanent strand of human history" (Chomsky 1987b, p. 29; 1973, p. 371). Reflecting the human aspiration to freedom, this tendency underlies the emphasis on freedom as the supreme value in assessing social forms, and encourages scepticism about familiar contentions of the "necessity" of social arrangements constraining freedom. To endorse anarchism in this sense is straightforward enough; it amounts to endorsing a critical standpoint in social thought and action, rooted in a concern to eliminate unnecessary constraints on human freedom.

The second sense in which Chomsky (more tentatively) invokes anarchism is less straightforward. Here anarchism does appear as a substantive, libertarian-socialist, ideal of social order. Chomsky's anarchism is socialist in that it endorses the social ownership of the means of production, a form of ownership permitting the extension of democratic procedures to economic decisions both in individual workplaces and across

the economy as a whole. What that means in detail is not explored at any length in his writings, but the essential principle is clear enough.

The content of the more specifically anarchist aspect of his views, however, is less clear. The basic idea of anarchism is that social cooperation can and should proceed without a state. But the content of that idea depends on the underlying conception of the state and its offending aspects – what is to be eliminated – and this has no single interpretation within the anarchist tradition. To locate Chomsky's views, it may help to begin by distinguishing three aspects of states that an anarchist might seek to eliminate – that states exercise coercive power at all, that they claim a legitimate monopoly on the exercise of coercive power, and that they specialize in the exercise of coercive power.[11] Corresponding to these three aspects of states are three distinct visions of social order, each of which has a claim to capture the basic anarchist ideal of state-free cooperation.

37.2.1 Conceptions of the State and Social Order

The first conception is a coercion-free system. In such an order there is no state, in that socially organized coercion does not exist at all and is in fact unnecessary, since the members willingly comply with rules and standards that are publicly announced.[12] Chomsky's endorsement of anarchism seems not to depend on the thesis that a coercion-free system is possible. For example, he often cites the 1936 Spanish anarchist experiments as exemplary of anarchist practice, but they were hardly free of coercion (Chomsky. 1969, pp. 72–124) Furthermore, while he assumes that an anarchist order will reflect and further a "spiritual transformation" of human beings, registered in much greater self-confidence and voluntary cooperation among them (Chomsky 1981/84, p. 260), he seems to agree that it would be unreasonable to expect complete civic consciousness and a fully harmonious coordination of interests in a social order that operates on the scale of a modern society.[13] Thus he notes the likelihood that (in part because of popular empowerment) "factions, conflicts, differences of interest and ideas and opinion" will be expressed throughout a libertarian socialist society (Chomsky 1981/84, p. 250).

Especially given his recognition of such a high degree of disagreement and conflict, it seems safe to assume that Chomsky recognizes as well the need for the continued existence of some agencies with powers of enforcement – if only to assure those who were willing to comply that others would not take advantage of their compliance.

A second possibility, then, is a dispersed-coercion system. Recognizing the need for powers of enforcement, but concerned about the dangers of a concentration of power,[14] the anarchist might identify the ideal of statelessness with a condition in which no single institution successfully claims a legitimate monopoly on the use of force. Instead, enforcement powers would be dispersed across a set of institutions, each of which would nevertheless be specifically political – that is, defined chiefly by its administrative and enforcement powers. One example of a dispersed-coercion system might be an order governed by a variety of administrative agencies, each with its own enforcement capability.

Another would be a territory featuring a variety of specifically protective associations, each providing security for certain people in the territory, but none with a monopoly on powers of enforcement.[15] But this view also fails to capture the core of Chomsky's anarchism. To see why, let us contrast it with a third interpretation of the ideal of state-free cooperation.

This third possibility is a system with dispersed coercive powers, but in which those powers, and all other traditionally political powers of collective decision-making and administration, are dispersed over institutions that do not specialize in the performance of political functions. Rather, on this conception, which we take to be Chomsky's own, political powers are exercised by institutions that also, and perhaps chiefly, perform other (for example, productive, associative) functions. Here, the "statelessness" of society is achieved neither by the abolition of coercion (the coercion-free system), nor by the multiplication of its authoritative dispensers (the dispersed-coercion system), but by the transcendence of the traditional division of labor in governance between specialized political institutions that rule, and the rest of a society subject to their rule.

Several elements of Chomsky's view underscore the importance of the elimination of specialized political institutions, the distinguishing feature of this third interpretation of anarchism. Thus, he supports political representation, but imagines representation to be based on such "organic groups" as workplace or community associations, and to feature a "rather minimal" delegation of powers (Chomsky 1981/84, 249). He sees the need for administration, but thinks that it ought to be a rotating "part-time job" performed only "by people who at all times continue to be participants in their own direct activity" (that is, who act in other capacities as well) (Chomsky 1981/84, 251). And while he does not think that political parties could legitimately be banned in an anarchist order, he does think that if parties, or any other specialized organizations with an exclusive devotion to political affairs, were "felt to be necessary," then "the anarchist organization of society will have failed" (Chomsky 1981/84, p. 250).

Within this conception, for example, workers" councils and their representatives might have responsibility for economic planning, and the elaboration and enforcement of rules governing workplace relations (such as rules on occupational safety and health). Tasks traditionally assigned to local governments (the maintenance of local order, sanitation, primary education and the like) would devolve to neighbourhood associations composed of citizens active in other affairs. Regional and national tasks of government would be handled through recallable representatives of such groups. National defence would be assured through citizen militias. And so on. What is essential is that all traditional functions of government would be discharged by groups whose members also engaged in non-governing activities.

How plausible is this conception? Anarchist views are typically criticized for resting on implausible accounts of human motivation, for being inattentive to the ways that decentralization can exacerbate political and material inequalities, and for ignoring the attractions and requirements of economic efficiency. Chomsky's conception avoids at least the most obvious versions of these objections. As noted earlier, for example, he appears to reject accounts of human motivation that would deny the persistence of conflict and disagreement under anarchy. He endorses the idea of a framework of basic rights, and reasonably encompassing arrangements for making collective decisions and administering those decisions, and in these ways addresses some concerns about the pathologies of decentralization. And, responding to concerns about economic efficiency, he stresses that his view does not imply primitive communitarian economic production (the denial of all economies of scale and specialization), and indeed welcomes technological development and increased productivity, which contributes to free social cooperation by limiting the need for human toil. In fact, he thinks that anarchism really comes into its own as a social ideal only with a high level of development of the productive forces of society.

37.2.2 The Weaknesses of Chomsky's Anarchism

We, however, are less convinced than Chomsky of the attractions of anarchism, for three reasons. First, we are simply unpersuaded that policies of, for example, economic coordination, environmental protection and public health are most efficiently made in the absence of specialized bodies, devoted to formulating policy alternatives and to assessing the likely consequences of their implementation. Assuming conditions of large-scale social interdependence, there are likely to be problematic third-party effects or "externalities" in each of these areas (for example, a significant degree of pollution, affecting large populations, resulting from the actions of individuals and enterprises).

Such externalities, and the complex problems of policy planning and evaluation they pose, are not solely attributable to "the irrational nature of [present] institutions" (Chomsky 1981/84, 250) and the incentives to selfish behaviour that they generate. In some important measure, they are intrinsic to social interdependence itself. If only because of problems of imperfect information, they can be expected to appear in an interdependent and technologically advanced society even under the most favourable of motivational conditions (for example, perfect altruism). Given the persistence of externalities and their attendant complexities, however, we doubt that any reordering of social institutions, however welcome, will simplify public policies to the point that reasonably efficient governance can become simply a "part-time job" (Chomsky 1981/84, 251).

Second, we would expect tensions between the proposed dispersion of political responsibility and the effective exercise of that responsibility. Underlying this concern is our assumption that actions needed to enforce the terms of order would be costly; that is, both detecting violations and sanctioning violators would generate costs for enforcers. For reasons familiar from the theory of public goods, the coexistence of dispersed benefits (those accruing to citizens in general from enforcement of the terms of the order) and concentrated costs (incurred by those who engage in enforcement) presents a situation ripe for "free-riding," and a concomitant failure to provide appropriate levels of enforcement.

Such problems are, it should be said, much less pervasive in smaller-scale associations. Reduction of scale almost certainly makes violations more apparent, thus reducing the cost of their detection. And since association norms can be invoked in a process of informal sanctioning, this is also likely to reduce the cost of imposing sanctions, including sanction of those who decline to sanction others. But we are assuming a fairly large and complex association. Here, we believe, the problem of providing incentives to enforce the terms of the order has real bite. And here, a natural solution to the enforcement incentive problem is to establish specialized agencies for administration and enforcement.

The specialization of agencies eases the task of providing incentives to enforcement, since those who work in them can be held accountable for their failures (for instance, by being removed from their positions). And it greatly simplifies the problem of monitoring enforcement performance, since the division of political labour enables citizens and their representatives to focus their inquiry on particular institutions and individuals.

Third, we doubt whether the proposed anarchist order would encourage the motivations necessary to its stability, in particular whether it would encourage the formation of a sense of justice comprehensive enough to include all members of the order. We noted earlier that Chomsky supposes that an anarchist order will encourage a "spiritual

transformation" of human beings. But it remains unclear how the sort of anarchism he endorses would elicit motivations of the required kind. In particular, we assume that a stable democratic socialist scheme must ensure continuing relative equality among the participants in the order. It might be the case, for example, that considerable portions of the surplus generated in some enterprises would be used to benefit those in others. But how is a concern to preserve such equality of condition to be encouraged among citizens, assuming (what seems obvious) that it could not be counted on to emerge spontaneously?

Presumably the idea is that citizens acquire a sense of justice and a willingness to act on that sense through the normal course of their maturation. But if organic groups, based in particular workplaces or neighbourhoods, provide the basis of political cooperation, then it would seem natural that the principal allegiance of citizens would be to those organic groups. And if that were true, then a sense of justice supporting the distributive measures required to maintain the order would not be likely to form. One of the virtues of less organic and more "alienated" political forms that are abstracted from everyday life – political parties, territorially defined representative bodies, and specialized organizations for making and enforcing collective decisions – is that they plausibly encourage the members of society to regard one another as equal citizens, deserving of justice whatever the particulars of their aspirations, class situation, or group affiliations. It seems likely that some such more cosmopolitan sense of citizenship, encouraged by less organic forms of political association, is necessary to provide the motivation needed to sustain the egalitarian background required of a genuinely democratic society.

Of course it may be that the establishment of specialized political bodies to address these problems would engender a concentration of power, and that such a concentration would produce greater threats to human freedom than those resulting from the absence of specialized political arrangements. This is, clearly, an empirical issue, and one about which we can only hope someday to have data. In the absence of more compelling evidence than we now have, however, Chomsky's anarchism seems to stand on relatively shaky grounds. This limits its appeal even to those who share his commitment to eliminating unnecessary constraints on human beings, and in particular constraints deriving from economic inequality.

37.3 What, If Anything, May We Hope For?

Setting these particular criticisms aside, Chomsky's account of human nature and the social conditions appropriate to its full expression naturally suggest two questions about contemporary societies. First, why are present social arrangements and the distribution of basic material resources and political power they provide so distant from the arrangements and distribution appropriate to human nature?[16] Second, given the distance between the actual and ideal, what reason is there for maintaining even the hope that current arrangements will come to approximate this ideal more closely? In this final section, we consider these questions in turn.

At least at an abstract level, Chomsky's answer to the first question is clear. Once an unjust order exists, those benefiting from it have both an interest in maintaining it and, by virtue of their social advantages, the power to do so. Maintenance is of course not in the interest of those who do not benefit from the order. So, dominant groups must use their power against subordinate ones to ensure the latter's consent or acquiescence

to the unjust scheme. The basic mechanisms for achieving this are force and fraud. Either those who do not benefit must, in effect, be frightened and beaten into submission, or they must be distracted from their real interests and deliberately confused about the way the world works.

More particularly, Chomsky believes that the relative importance of force and fraud to social reproduction depends on the specific scheme of unjust distribution in place. Fascist orders and Stalinist "socialism" are marked by the denial of liberties of expression, association and participation. Thus, while they feature well-developed propaganda systems, they rely primarily on force to suppress the natural aspiration to freedom. Capitalist democracies, by contrast, provide at least formal rights of expression, association and participation. While they feature considerable use of force, the availability of channels of expression and association increases the importance of what people think, and fraud accordingly plays a more central role in preserving order (Chomsky 1984, 131–132; 1991, ch. 12). In capitalist democracy, the real "enemy" of governing elites, their "ultimate target', is the human mind itself (Chomsky 1985, 234–236). The preservation of unjust advantage requires thought control, the deliberate "manufacture of consent."[17]

In elaborating these themes, Chomsky has focused principally on the role of the mass media in capitalist democracies, and then almost exclusively on the case of the media in the United States – a case marked, in comparative terms, by an apparently paradoxical combination of extreme media servility and minimal state control of those media.[18] These writings, some authored jointly with Edward Herman, present a "propaganda model" of the media's operation – not, it may be stressed, of its effects on consciousness or behaviour (see discussion below, p. XXX) – with two component parts.[19]

… [sections on "The Propaganda Model," "An Overstated Case," and "Ideology and Consent" omitted here]

37.4 Expanding the Domain of Freedom

We come, finally, to Chomsky's views on social evolution, and the second question posed at the outset of this section. Why should one think that existing societies, structured in ways so hostile to the exercise of human freedom, might change in a direction more in keeping with that essential human capacity? Our discussion of Chomsky's view of social order (even admitting the amendments to that view we have suggested) underscores the force of this question, for it may suggest that he sees dominant groups as in some sense invincible. In light of that discussion, it is easy to see why he believes that the "struggle for freedom and social justice" is "unending, often grim" (Chomsky 1970/73, 406), and why political actors face "temptations of disillusionment . . . many failures and only limited successes" (Chomsky 1985, 253). But it may be more difficult to understand why he also thinks the struggle against oppression is "never hopeless" (Chomsky 1970/73, 406; 1991, 64), or to understand the grounds for his

> hope that our world can be transformed to "a world in which the creative spirit is alive, in which life is an adventure full of hope and joy, based rather upon the impulse to construct than upon the desire to retain what we possess or to seize what is possessed by others."
> --Chomsky (1971), quoting Bertrand Russell

In Chomsky's view, the source of hope lies in human nature itself. He speculates that constraints on human freedom that are not "required for survival in the particular

state of history" will tend to be sloughed off, as a result of the moral nature of human beings, the "instinct for freedom', and the "continual efforts to overcome authoritarian structures and to expand the domain of freedom" that result from that instinct (Chomsky 1988a, 469). Put otherwise, systems that impose unnecessary constraints on natural tendencies to human expression will, by that very fact, face intrinsic sources of instability. The significance of these destabilizing pressures for reform will of course depend on a range of factors relevant to political mobilization – including the number of people who feel the constraints of existing order, the capacities for and willingness to pay the costs of collective action on the part of those who do, the willingness of dominant groups to repress or murder their own populations, the power of foreign states to thwart mass action, and the strategic choices of opponents of oppressive regimes. Still, such pressures are present, and their presence suggests a weak evolutionary tendency toward societies more accommodating of human freedom.

Illustrating these claims about basic human nature and the pressures it exerts on unjust arrangements, Chomsky (1987, 49) suggests, for example, that the "propaganda system" in the United States – its tremendous power and durability notwithstanding – is "extremely unstable because of the reliance on lies. Any system that's based on lying and deceit is inherently unstable." The thought that underpins this view is that lying about US policies (or disguising them in other ways, for example through covert action) is necessitated by the decency of the population, who if confronted with the truth would resist those policies. And elsewhere, in arguing (correctly, we believe) against the familiar "expert" view that the American public has recently shifted profoundly to the right on social and foreign-policy questions, he notes the continuing dissent of the population from many of the more brutal aspects of recent US policy, "despite all the brainwashing and indoctrination and so on" (Chomsky 1988a, 735; 1991, 173). Here again, such resilient decency, and the threat it poses to indecent institutions and policies, derive from our moral nature and our fundamental aspiration to freedom.

More broadly, Chomsky rejects the currently fashionable neo-Nietzschean view that the history of the world is merely a history of change, in which old forms of domination are simply replaced by new ones, without significant progress in meeting such fundamental human interests as the interest in freedom.[20] A "child of the Enlightenment" (Chomsky 1988a, 773), he finds instead that human history, at least at some moments, exhibits "detectable progress in the guarantee of fundamental human rights, difficult as it may be to pronounce such words in the century that has given us Hitler and Stalin, agonizingly slow as the process may be" (Chomsky 1989, 355). Such progress reflects "continual efforts to overcome authoritarian structures and to expand the domain of freedom." And those efforts, in turn, "probably (reflect) instinctual patterns that are just part of our moral nature" (Chomsky 1988a, 469).

To us, Chomsky's (1988b, 154) "optimistic view" seems highly plausible. As noted earlier, a fundamental human interest in autonomy and capacity for moral judgment appear to have played a significant role in many historical achievements in the cause of human freedom (for example, the abolition of slavery, the extension of religious and political toleration).

Despite the murderousness of the twentieth century, such aspirations and capacities have clearly been operative in many of the great political struggles of the recent past – from Third World efforts to break free of colonial bondage, to the civil-rights movement in the US, the worldwide movement for women's liberation, or the revolution

against Stalinism in Eastern Europe. And whatever the political doldrums of the present, there is every reason to think they are operative now.

Chomsky (1987, 48) has disavowed a "faith" in any project or tradition, including a faith in reason itself. But his weak evolutionary theory suggests a "reasonable faith"[21] in human beings that works in support of hope about social advance.[22] While the evidence about people is not decisive, nothing that we know about human nature is inconsistent with the contention that aspirations to freedom and decency are fundamental features of that nature; and nothing that we know about social order defeats the hope that the pursuit of these aspirations will produce significant improvement in human circumstances. The fact that such hopefulness is consistent with the evidence enables children of the Enlightenment to be optimists of the will, without condemning themselves to being irrationalists of the intellect. It is Chomsky's insistence on this point, his commitment to both reason and moral hope, that we take to be his signal contribution to social thought.[23]

Endnotes

1 Chomsky 1967/69, 325. References to Chomsky's work here are intended only to support the claims we make about his views, not to provide an exhaustive inventory of relevant passages.

2 Chomsky also, of course, has long engaged in more direct forms of political activism, including civil disobedience.

3 Chomsky's own work in linguistics may be understood as a contribution to the development of such a theory, but he would be the first to assert its distance from a complete and systematic account.

4 On the background in rationalism and romanticism, see Chomsky (1966; 1970/73, 402–403; 1972, 76–77).

5 In the case of language, Chomsky's idea was to secure the connection between creativity and rules – to show what enables us, as Humboldt put it, to "make infinite use of finite means" – by incorporating recursive rules into a representation of the grammatical knowledge of ordinary speakers. For discussion of the role of recursive rules in solving Humboldt's problem, see Chomsky (1965, 8; 1988a, 146) and the striking remark: "I think that the ideal situation would have been to have someone in 1940 who was steeped in rationalist and romantic literary and aesthetic theory and also happened to know modern mathematics." (Chomsky 1988a, 146).

6 The discussion that follows draws on various remarks that Chomsky makes about the connections between his views about language, human nature and politics. For a representative sample, see his (1966, 24–26, 91–93; 1970/73; 1976/87, 195–199; 1988a, ch 5; 1988b, 143–148, 240–246, 318, 385–387, 402–403, 468–469, 566–567, 593–594, 696–697, 755–756). In these passages Chomsky does not separate, as we do, issues of modularity and creativity in considering the relevance of the understanding of human language for a more general theory of human nature. But the passages listed above suggest the relevance of both, and they are, so far as we understand, independent. Thus, the existence of a visual module employing a rigidity principle in the interpretation of visual experience does not imply anything about the creative use of visual perception (whatever that might mean). And the absence of a module in a particular domain is consistent, at least in principle, with creativity since the latter might reflect general features of human reason (as Descartes seems to have thought). Finally, the relevance (such as it is) of the study of human language to a more general theory of human nature is not affected, so far as we understand, by the shift from a conception of language in terms of rule systems to Chomsky's more recent

"principle-and-parameters" view. For discussion of the shift in the account of language, see Chomsky (1986, 1988b).

7 Orlando Patterson emphasizes that slaves are characteristically represented as outsiders to the community that enslaves them, as "natally alienated." See Patterson 1982, ch. 2.

8 On enjoying the activities of others, see Chomsky (1976, 198–199). For discussions of the "Aristotelian principle" and its connection with the value of community, see Rawls (1971, 424–433, 523–525 (the background in Humboldt we noted in n. 5 above).

9 For discussion of these features and their relevance to historical sociology, see Moore (1978), Unger (1987), and Cohen (1997).

10 See Chomsky (1973, 404; 1976/87, 195; 1988a, 147)

11 Our discussion of Chomsky's anarchism has been greatly aided by Taylor (1982).

12 Alexander Berkman (1972, 182), for example, asserts that "Anarchism teaches that we can live in a society where there is no compulsion of any kind."

13 Drawing on a range of anthropological and historical studies, Michael Taylor argues that virtually all anarchist communities have relied on some scheme of social controls (threats and offers of sanction) to ensure compliance, and not simply on socialization and education. See Taylor (1982, 39, 76ff.).

14 Chomsky commonly emphasizes a general concern about concentrated power, suggesting that the nineteenth century libertarians focused on concentrations of power in the State and Church, while twentieth-century libertarians (especially socialist anarchists) have extended such concerns to the concentration of economic power. See, for example, Chomsky 1981, 248; 1988a, 301, 744.

15 See, for example, the discussion of the possibilities of providing protection within a state of nature in Nozick (1974, 12–17).

16 Chomsky indicates that this question arises naturally, given his views on human nature; see Chomsky 1991, 397.

17 The term, taken from Lippmann (1922), provides the title for Herman and Chomsky (1988).

18 See, for example, Chomsky (1987), which notes that the US is near the "libertarian end in the spectrum of existing societies" (p. 114) but that debate proceeds" "within very narrow limits" (p. 124).

19 Herman and Chomsky (1988) use the term "propaganda model" to refer just to the first of the two components discussed in the text. For reasons of terminological convenience we use the term to cover a wider range of Chomsky's views about the media. We do not assume, however, that Herman embraces all aspects of the propaganda model as it is characterized here.

20 See, for example, Chomsky's (1977, 80) summary of his disagreements with Foucault.

21 The term comes from Kant (1788/1956, Pt I, Bk 2), who held that it is reasonable, on moral grounds, to have faith that God exists, that the will is free, and that the soul is immortal.

22 And, recently, he appears to acknowledge as much; see Chomsky (1991, 397–401).

23 We would like to thank Robin Blackburn, Robert Brenner, Edward Herman, Paul Horwich, and Carlos Otero for their comments on an earlier draft of this paper.

References

Berkman, A. 1972. *What Is Communist Anarchism?: Now and After: The ABC of Communist Anarchism*. New York: Dover.

Chomsky, N. 1966. *Cartesian Linguistics*. New York: Harper & Row.

Chomsky, N. 1972a. *Language and Mind*. New York: Harcourt Brace Jovanovich.

Chomsky, N. 1965. *Aspects of the Theory of Syntax*. Cambridge: MIT Press.

Chomsky, N. 1967/69. *The responsibility of intellectuals. The New York Review of Books, February 23, 1967. Reprinted in American Power and the New Mandarins, 323–66*. New York: Pantheon Books.

Chomsky, N. 1969. Objectivity and liberal scholarship. In *American Power and the New Mandarins*, 23–158. New York: Pantheon Books.

Chomsky, N. 1970/1973. Language and freedom. Abraxas, I 9–24. Reprinted in For Reasons of State, 387–408. New York: New Press.

Chomsky, N. 1971. *Problems of Knowledge and Freedom: The Russell Lectures*. New York: Pantheon Books.

Chomsky, N. 1972b. *Language and Mind*. New York: Harcourt Brace Jovanovich.

Chomsky, N. 1973. Notes on anarchism. In *For Reasons of State*, 370–86. New York: New Press.

Chomsky, N. 1976/87. Equality: Language development, human intelligence, and social organization. *In Peck* (1987), 183–202.

Chomsky, N. 1977/79. *Language and Responsibility: Based on Conversations With Mitsou Ronat. New York: Pantheon Books*. Translation of Dialogues avec Mitsou Ronat. Paris, Flammarion. p 1.

Chomsky, N. 1981. The relevance of anarcho-syndicalism. In *Radical Priorities*, edited by C. P. Otero, 245–261. Montréal: Black Rose.

Chomsky, N. 1987. The manufacture of consent. In *The Chomsky Reader*, edited by J. Peck, 121–136. New York: Pantheon Books.

Chomsky, N. 1985. Turning the Tide: U.S. Intervention in Central America and the Struggle for Peace. Boston, Mass: South End Press.

Chomsky, N. 1986. *Knowledge of Language: Its Nature, Origin, and Use*. New York: Praeger.

Chomsky, N. 1987a. *On Power and Ideology: The Managua Lectures*. Boston: South End Press.

Chomsky, N. 1987b. Interview. In *The Chomsky Reader*, edited by J. Peck, 3–55. New York: Pantheon Books.

Chomsky, N. 1988a. *Language and Politics*, edited by C. P. Otero. Montréal: Black Rose Books.

Chomsky, N. 1988b. *Language and Problems of Knowledge: The Managua Lectures*, Cambridge: South End Press.

Chomsky, N. 1989. *Necessary Illusions: Thought Control in Democratic Societies*. Boston: South End Press.

Chomsky, N. 1991. *Deterring Democracy*. New York: Random House.

Cohen, J. 1997. The arc of the moral universe. *Philosophy & Public Affairs* 26 (2): 91–134.

Herman, E., and N. Chomsky. 1988. *Manufacturing Consent: The Political Economy of the Mass Media*. New York: Pantheon

Kant, I. 1788/1956. Critique of Practical Reason, trans. Lewis White Beck, Indianapolis: Bobbs-Merrill.

Lippmann, W. 1922. *Public Opinion*, Boston: Harcourt Brace.

Moore, B. 1978. *Injustice: The Social Bases of Obedience and Revolt*, New York: Routledge.

Nozick, R. 1974. *Anarchy, State, and Utopia*, New York: Basic Books.

Patterson, O. 1982. *Slavery and Social Death: a Comparative Study*. Cambridge, MA: Harvard University Press.

Peck, J. 1987. The Chomsky Reader, edited by J. *Peck*, New York: Pantheon.

Rawls, J. 1971. *A Theory of Justice*, Cambridge: Harvard University Press.

Taylor, M. 1982. *Community, Anarchy, and Liberty*. Cambridge: Cambridge University Press.

Unger, R. 1987. *Politics: A Work in Constructive Social Theory. Vol I: False Necessity*. Cambridge: Cambridge University Press.

Part VIII

Reflections

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Reflections

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It is, needless to say, very gratifying to see this comprehensive collection of thoughtful chapters relating to the "generative enterprise," as it was called by Henk van Riemsdijk and Riny Huijbregts 40 years ago.

In these remarks I won't try to go into the many fascinating topics discussed in the papers, but rather, will add some thoughts about questions that have persisted in the background from the days when the enterprise began to take shape 70 years ago, and that remain alive, even if in somewhat different forms.

One basic question is: "What is a theory of language?" And more fundamentally: "Is there a theory of language?" The latter question makes sense, even assuming the existence of language (itself a vexed question and one rarely addressed in any useful form, the record indicates). The relation between "theory of language" and "language" is asymmetrical. There can be no theory of language without language, but it's perfectly coherent to hold that language exists in some form but that it is idle, even seriously misguided, to seek a theory of language. In fact, this position is implicit in the procedural approaches to language that were the major component of the work in structural linguistics, reaching their apogee in Zellig Harris's classic *Methods in Structural Linguistics* (Harris 1951),[1] which seemed to many to bring a kind of closure to the field, so understood.

The two most outstanding theoreticians of "post-Bloomfieldian" structural linguistics, Zellig Harris and Charles Hockett, adopted perspectives of this general nature in the mid-1960s, in different and instructive ways.

Harris's rejection of the search for a theory of language was explicit. He opens *Methods* by describing it as:

> a discussion of the operations which the linguist may carry out in the course of his investigations, rather than a theory of the structural analyses which result from these investigations. The research methods are arranged here in the form of the successive procedures of analysis imposed by the working linguist upon his data. (1951, 1)

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Alternative procedures may be quite legitimate, yielding different analyses of phonemic or other structures. In 1965 Harris took a stronger position: there are no "competing theories"; "pitting of one linguistic tool against another" is senseless, an "aberration" with sociological roots. Alternative procedures of analysis can be applied "as a basis for a description of the whole language," bringing out its various properties.

From this point of view, language exists – or at least linguistic behavior does – but there are no theories of language. Though it is not entirely clear what language is, we can distinguish linguistic from other forms of human behavior, and we can exhibit its properties in different ways, none having a privileged position (Harris 1951, Harris 1965).[2]

At about the same time, in the late 1960s, Charles Hockett, who devoted more careful and sophisticated attention to these issues than anyone else, held that it is "nonsense" to suppose that a speaker of a language has acquired anything like a grammar, coded in the brain, which determines, for example, that this sentence is well-formed with a specific range of interpretation, while the same string of words read backward has a radically different status (Hockett 1968).[3]

Hockett adopts the general American structuralist consensus based on Leonard Bloomfield's conception of language as "a matter of training and habit" (Bloomfield 1933).[4] Hence, he understands a language to be a "set of habits," changing constantly. Speech is produced on the basis "of habits – that is, of analogies" (and "blending," a marginal process). Sentences are produced and understood on the basis of "analogies" from a "stock of already-familiar forms." It might be possible, he suggests, to entertain the hypothesis (untestable at present) that "the brains of speakers and hearers coin and understand on the basis of 'abstract patterns' of some sort, extracted over the months and years of language-acquisition and language-use from actual utterances of similar shapes." But this remote possibility would not require "an additional independent mechanism for the generation of speech," only further resort to analogy and "abstraction" (both notions left unanalyzed).[5]

The habits that constitute language are acquired by the child by "cultural transmission." Beyond that, language acquisition relies only on "the basic ability to acquire a language," apparently some general mode of habit formation that is applied in the special case of language. Analogy too is presumably some general cognitive capacity.

From this perspective, it is also nonsense, Hockett observes, to suppose that a language has an infinite number of sentences, since habits of speaking have temporal bounds (memory, death, etc.).

Notice that while Harris and Hockett reject the generative enterprise as nonsensical, they differ in how they regard language and theory of language. Hockett adopts a "realist" stance. Language is somehow coded "in the head" as a constantly changing set of habits, hence a biological trait of individuals. Theories of such biological traits can be compared for accuracy, an idea that Harris dismisses. The difference was described at the time as "hocus pocus" vs "God's truth" linguistics, Fred Householder's ungenerous terms. The distinction was often posed in terms of whether the structure of language is real or imposed by the analyst; sometimes explicitly in Hockett's terms of neural representation though the realist assumption seems implicit in any interpretation of language as a system of habits. Whether there is a theory of language beyond the general theory of neurally coded "sets of habits" (analogies) seems to be left open.

Hockett comments that "by 1950, West of the Atlantic, we had reached what seemed to be a reasonable working consensus on these matters," with only some technical matters unresolved. Much the same conclusion is reached by another prominent

theoretician, Martin Joos, who writes that descriptive linguistics in 1956 "seemed to be without a serious competitor" in the United States. It was solidly established for the first time as a true science, a "classificatory science" (in Hockett's phrase), a "taxonomic" science (Joos 1995).

Hockett's arguments are based on what he describes as a fundamental principle: no physical object, like the brain, can be well-defined. It will always be subject to "wear and tear," to "thermodynamic [and] relativistic indeterminacy," and other deviations from perfect functioning. Accordingly, he concludes, there can be no well-defined grammar formulating properties of language that are coded in the brain and that enter into production and interpretation of speech.

That is quite a far-reaching proposal. The same logic would appear to rule out the study of knowledge of arithmetic – for example, a child's knowledge that there is no largest number. Similarly, it rules out studies of the principles and mechanisms of insect navigation and communication or of visual perception (e.g. the rigidity principle, object constancy, the Marr program, etc.), all efforts to determine the actual computational procedures encoded in the brain while abstracting from many factors that enter into unanalyzed phenomena. It is not easy to see how Hockett's "classificatory science" of linguistics escapes this critique; any two utterances have distinct neural codings, so even the core procedures of phonemic analysis are unavailable without the kind of abstraction that Hockett rejects under the recommended version of "empirical science."[6]

Hockett describes his core objection as a demand to keep to the norms of science, part of the consensus of the Bloomfield-based structural linguistics of which he was, as noted, the most sophisticated exponent. If so, it is of a piece with Bloomfield's insistence on grounding the study of language in behaviorist doctrines, also a sharp departure from the approach of the sciences.

From this general perspective, even the most elementary results about language must be dismissed as nonsense since they are developed within a framework that is blocked in principle: the crucial competence–performance distinction – the distinction between what we know and what we do – which was made clear and explicit for the first time within the theory of computation along with the equally crucial distinction between generation and production. Its core contribution to the study of language and cognition generally was the concept of Turing architecture, a system with a stored program that is constrained by memory but proceeds with no change of program as these constraints are relaxed, as distinct from a system that is constantly revised as new data appears, such as the habit-based consensus that Hockett reviews.

Hockett was quite familiar with the theory of computation, and even has a tutorial chapter about it in his book. But within the habit-based framework of the structuralist consensus that he reviews, there is no place for its most important contribution to the study of language. A standard illustration at the time Hockett wrote was depth of embedding. As George Miller and I had shown, embedding is intelligible without external memory up to the general limit of short-term memory, and indefinitely beyond as memory is increased – much like our ability to multiply (Miller and Chomsky 1963; Chomsky 1965). None of this shows up in a corpus or our "habits of speaking," which naturally avoid complexity, a matter with no bearing on what we have internalized. All of this remains complete mystery within the habit-analogy framework. Interestingly, failure to grasp these simple points persists in much current work.

The consensus considered the basic notions of habit and analogy to be clear enough for the purposes of the linguist and scientists in related disciplines. There plainly are

many obscurities. Thus consider the idea that speaking and understanding are based on a "stock of already-familiar forms" that supply "the bases for the various analogies, in the head of the speaker." Or perhaps "abstract patterns" derived by analogy, in some way not yet understood. How is the stock of forms or patterns stored "in the head of the speaker"? It cannot be some astronomical list of sentences remembered from previous occasions, or of "patterns" (also an astronomical list). What are the "forms" and "patterns" that are the basis for the analogies/habits that are used? How do they yield the analogies that are required? How does the inductive leap take place in the specific way it does? More generally, what can we explain about the nature of language, or particular languages, or acquisition, or use in these terms?

The last concern came to prominence sharply with the first modern efforts to go beyond taxonomy to explanation of properties of language by means of a generative grammar, a theory of the language for which considerations of explanatory adequacy at once arise. It quickly became clear that the entities that enter into an explanatory theory of this kind could not in principle be discovered by the procedures of taxonomic linguistics. There was, it seemed, an unbridgeable gap between the procedural approaches of the consensus and the search for explanatory theory – not a problem of course if there are no theories of language apart from the general theory of neural coding of habits (or at all, in Harris's conception).

Ideas similar to the structuralist consensus soon became familiar in philosophy of language. W.V.O. Quine, one of the most influential philosophers of language in the mid-twentieth century, and one of the few to take up these questions directly, adopted a stand not unlike Bloomfield's. Rather like Bloomfield's conception of language as "a matter of training and habit," Quine took a language to be a "complex of dispositions to verbal behavior, in which speakers of the same language have perforce come to resemble one another" (Quine 1960, p. 27). – a complex established by Skinnerian operant conditioning, he elsewhere elaborates. And like Bloomfield (see note 4), he elsewhere takes a language to be a set of "significant sequences, [which,] being subject to no length limit, are infinite in variety" (Quine 1953, p. 53), raising the same questions of consistency as for Bloomfield. David Lewis later took the same view in an influential article: language is an infinite set of sentences used by a population. Both Quine and Lewis conclude that while it makes sense to say that a population uses this infinite set, it doesn't make any sense to say that there's a right or wrong way to characterize the set. To look for that, Quine said, would be "folly." Lewis wrote that he could make no sense of the notion. Quine and Lewis left unclear how these infinite sets are specified apart from "having meaning in the language" (Lewis 1975).[7]

The American structuralist consensus, and the serious questions that it left unanswered, were part of the background for the generative enterprise, which began to take shape in Cambridge, Massachusetts, in the early 1950s, along with the "cognitive revolution." The consensus was, in fact, virtually absent from Cambridge. It happened to be my personal background (I was then a graduate student at Harvard), but that was about all from West of the Atlantic. Roman Jakobson, also at Harvard, represented the European structuralist tradition, along with his student and collaborator Morris Halle.

There were, however, other lively currents, with their own concepts of language and theory. One was behaviorism, in the radical behaviorist form developed by B.F. Skinner. His 1947 William James lectures, the source of his later publication *Verbal Behavior*, was widely circulated and highly influential, in large part thanks to its advocacy by W.V.O. Quine, who was then lecturing on what later appeared as *Word and Object*, adopting the

Skinnerian paradigm.[8] Another current was based on engineering and mathematics: Norbert Wiener's cybernetics and Claude Shannon's information theory. This work was widely regarded as providing a plausible framework for integrating the social and emerging cognitive sciences more generally.

Roman Jakobson's 1949 formulation of the European "*structuralist* or *functional*" tradition (in his words) found its place within the evolving Cambridge framework: "the common denominator of the various trends in the modern science of language … [is that] language is primarily interpreted as a *tool of communication*, and its structure is analyzed in the light of the purposes that it and is components serve" (Jakobson 1990, Chapter 1.).

In general, there was a feeling of euphoria and anticipation of major achievements in what had been taken to be the study of mind. Prevailing attitudes are well captured in a retrospective discussion by Israeli logician Yehoshua bar-Hillel, who was a regular visitor at the Research Laboratory of Electronics (RLE) at MIT, the interdisciplinary research institution that was one of the major centers of these developments:

> There was a ubiquitous and overwhelming feeling around the Laboratory that with the new insights of cybernetics and the newly developed techniques of information theory the final breakthrough towards a full understanding of the complexities of communication 'in the animal and in the machine' had been achieved. Linguists and psychologists, philosophers and sociologists alike hailed the entrance of the electrical engineer and the probability mathematician into the communication field. (Bar-Hillel 1965, reprinted as Bar-Hillel 1971).

The concept "communication field" was understood very broadly, as indicated by the range of professions mentioned.

A few were highly skeptical, not of the achievements of information theory and cybernetics but of the anticipated breakthrough based on these ideas. The skeptics included three graduate students who met at Harvard in 1951, and quickly became close friends: Morris Halle, Eric Lenneberg, and me. A few years later, Eric went on to medical school and founded the modern field of biology of language (Lenneberg 1967). Morris and I worked closely together until his last days. Yehoshua also was then and remained a close personal friend. By the time his retrospective was written, he had come to share this skepticism to a fair degree.

The generative enterprise grew from these skeptical roots, including dissatisfaction with the taxonomic consensus in linguistics and, in particular, its apparent inconsistency with the search for explanation. In some cases, proposals were clear enough so that they could be refuted outright; the prevailing Markovian conceptions of language use, for example. Others were undermined in ways I won't review here (Chomsky 1964). By the mid-1950s, the enterprise was beginning to reach beyond RLE. A concept of language and theory of language was taking shape within what later was called the *biolinguistics framework*, the term proposed by Massimo Piattelli-Palmarini. It shared with the Bloomfield-Hockett tradition the realistic conception that the basis for language is coded in the brain, but followed normal scientific practice in abstracting from irrelevant factors to seek explanatory theories of language (in the form of generative grammars) and general principles of language.

Principles are sought at two levels: at one level for individual languages and at a deeper level for the faculty of language itself – for *Universal Grammar* (UG), adapting a traditional term to a new framework. The approach assumed general Turing

architecture and distinguished competence from performance and generation from production, distinguishing the stored internal linguistic system from the ways it is accessed for production and perception, integrated with other factors.

From this perspective, both language and theories of language exist. Theories arise at two levels, for each language and for UG, the latter apparently a species property with no known group differences and isolated in essentials in the biological world. Language is understood to be an internal property of an individual, much like the visual system, the immune system, the enteric nervous system ("gut brain"), etc. Both language and theory of language were referred to by the systematically ambiguous term *grammar*. To overcome the confusion, I suggested later that the term *grammar* be reserved for the linguist's theory, conforming to traditional usage, and that the language be called *I-language*, "I" to suggest internal, individual, intensional (in the sense of "function in intension"; we seek to discover the actual mode of computation, not just what is enumerated).

Furthermore, much as in the case of the visual system and others, what is coded in the brain of the individual results from several interacting factors: (1) innate structure, (2) external data, and (3) elements that lie outside of the system under discussion. For a computational system like language, the third factor includes principles of computational efficiency along with special properties of the brain and other cognitive processes. There is by now extensive evidence of the role of computational efficiency in the growth and function of I-language, and just the beginnings of evidence of independent cognitive processes and neural properties.[9]

Within this general framework, we then face the normal tasks of theory construction. Its goal is explanation, which relates closely to simplicity, matters examined in some depth in the 1940s and 1950s by Nelson Goodman and a core concern from the first attempt to construct generative grammars 70 years ago.[10] This concern entails unearthing and addressing hidden assumptions, not a simple task as the record indicates, and one that remains challenging today.

There are also special concerns following from the biolinguistic framework, the "realist" conception of I-language and faculty of language. Adopting it, we seek a theory UG of the initial state of the faculty of language that meets the conditions of learnability and evolvability. It must provide the innate basis for acquisition of language within the empirical constraints revealed by study of the process, and a plausible picture of how UG might have evolved.

While these conditions were recognized from the start, attention was largely focused elsewhere, for good reasons. As soon as the first efforts were undertaken to provide some substantive alternative to such concepts as "habit" and "analogy," it became very clear that the consensus was far off base in believing that basic questions were mostly answered and that what remained was to apply the procedures that had been developed to new materials and to fill in the gaps in the taxonomic science that was pretty much in place. It quickly turned out that very little was known and understood – that the procedures that had been developed were quite limited and had fundamental flaws, and could not even provide the entities that enter into explanatory theory.

The first efforts were therefore focused on developing concepts rich enough to at least capture the phenomena of language, with longer-term goals sidelined temporarily. It also became clear that the study of learnability faced an enormous problem of "poverty of stimulus" (POS); data available to the child do not come anywhere near accounting for what young children know and understand. No imaginable

general mechanism of learning, conditioning, or habit formation could come close to handling the most elementary examples, from acquisition of words on to further properties of what the child quickly attains. Recent statistical investigation of actual materials available to children shows that data are far more limited than had been assumed (Yang 2013) and extensive studies of child language have revealed richness of knowledge and understanding at a very early age, thus radically extending the POS problems.

Recognition of these issues about acquisition seemed to require that UG be highly complex to account for the inductive leap, but that tends to undermine the goal of evolvability, increasingly so in recent years with new evidence appearing about evolution of language, apparently quite recent in evolutionary time, at about the time of appearance of *Homo sapiens* and in place before separation of small groups not long after, so genomic evidence reveals (Berwick and Chomsky 2016, Huybregts 2017).

Pursuit of the enterprise therefore followed two paths: (1) expansion of coverage to a wide range of typologically varied languages, and (2) refinement of descriptive devices to satisfy the conflicting demands of learnability ("explanatory adequacy") and evolvability, the latter in the background until recently.[11]

Early work used the devices of phrase structure grammar (PSG) and transformations. It was understood that both were far too rich. PSG permits impossible rules and incorporates many hidden assumptions (why not a rule NP → P VP? How is VP → V NP different from X → V Z?). PSG was eliminated in the 1960s, and efforts were underway from the early 1960s to reduce the overly rich power of transformations. I won't run through the work that followed.

By the 1990s it seemed reasonable to me and some others to consider the thesis that the core part of language, the operations that generate expressions of thought (narrow syntax[12]) might approach perfection from a computational perspective (the Minimalist Program). Pursuit of this program breaks new ground, I think, in reaching genuine explanations: that is, explanations that satisfy the twin conditions of learnability and evolvability, the "holy grail" from the earliest days. If correct, these conclusions constitute a new and exciting stage in the long and rich history of study of language.

The optimal result would be explanations that involve no learning at all and that make use only of operations that must have evolved if language is to exist at all. There is at least one such operation: the minimal computational operation, binary set formation ("Merge" in recent usage). Hence the conditions of learnability and evolvability would be met (vacuously) by an explanation that relies solely on Merge and third-factor properties, restricting the second factor to providing data with the triggering effects that are normal for innate properties.

Remarkably, a good deal follows from just the assumption that I-languages are generated by Merge.

In the first place, that suffices to yield at least the skeletal structure for what has been called the Basic Property of Language: the fact that an I-language consists of an unbounded set of hierarchically structured expressions, each a linguistic articulation of thought, each potentially externalized to some sensorimotor system SM, which imposes arrangements required by SM (including linear order, so it appears). SM is typically the sound system, but it is now known that signed language is essentially the same as spoken language in all significant respects, and that even touch can be used (with some limits). I-language is rather like a stored program in a laptop that can be hooked up to different printers.

Second, we derive the ubiquity of displacement, always regarded (by me in particular) as a strange imperfection of language, but in fact produced by the most parsimonious subcase of Merge (internal Merge, IM). The question is why there is ever resort to the second subcase of Merge (external Merge, EM), which yields compositionality. The answer follows from the external requirement that thoughts require argument structure, not provided by IM, and more generally, from the principle of duality of semantics (Chomsky 2007, 2016).

Third, displacement automatically provides the basis for "reconstruction" – the fact that displaced phrases are interpreted where they are not heard – without the need for special rules.

Fourth, we derive the curious property of structure dependence, known by infants without relevant experience, a property that entails that in applying syntactic or interpretive operations, the child ignores 100% of what it hears (linear order) and attends only to what it never hears (structures constructed by the mind). It follows also that linear order and other arrangements (like those used in sign) are not strictly speaking part of language proper, but are rather imposed by the SM systems used for externalization, systems that were in place long before language emerged and are unaffected by it.

A further consequence, supported by much other evidence, is that the modern doctrine that language is essentially a tool of communication is misguided. Language can of course be used for communication but its basic design ignores this function, and in keeping to the simplest design, nature appears to have endowed language with properties that impede communication.

A more technical conclusion is that the only admissible subcases of Merge are the earliest ones assumed, internal and external Merge. Various extensions of Merge that have been investigated can be shown to be illegitimate. They yield valuable descriptions, but fall short of genuine explanation of the kind that can attained in some core cases.[13]

More recent theoretical work, which I cannot review here, examines hidden assumptions that still have not been recognized and eliminated, and that show up even in the best contemporary analyses of such simple sentences as "What should we do?" Dismantling of these assumptions suggests the need to revise and deepen current conceptions in ways that may significantly alter our understanding of language.

Increasingly, we are learning how to address a fundamental challenge posed early in the modern scientific revolution, when Galileo and the logician/linguists of the Port Royal monastery expressed their awe and amazement at the fact that language permits us to construct

> from 25 or 30 sounds an infinite variety of words, which although not having any resemblance in themselves to that which passes through our minds, nevertheless reveals all of the secrets of the mind, and makes intelligible to others who cannot penetrate into the mind all that we conceive and all of the diverse movements of our souls.
> (Arnauld and Lancelot [1660]1975; quoted at p. 125 of Chomsky [1966] 2006.)

Seventy years ago, the challenge (had it been known) would not have been taken seriously. There were answers: training, habit, conditioning, analogy. Prevailing assumptions were that the secrets of language – its nature, use, and acquisition – had been largely unveiled and that what remained was to clean up some loose ends and apply to new phenomena the methods of analysis and description that had been carefully crafted. The project was approaching a successful termination.

There are no such illusions today. To paraphrase the title of a famous history of science, as the generative enterprise began to take shape it soon became apparent that we had to leave behind a "closed world" in which everything was more less understood and enter an "infinite universe" that we were barely beginning to explore. By now we are beginning to understand some of the problems posed by the remarkable species property of human language. Investigations over a range never before contemplated have illuminated many aspects of language that were completely unknown not long ago. We can for the first time provide genuine explanations for some of the basic properties of language, also barely recognized until they were exposed in the course of the generative enterprise. New and exciting vistas are opening up, though some of the traditional concerns remain beyond our reach – perhaps, we may discover, for fundamental reasons grounded in our cognitive nature.

Endnotes

1 Completed in 1947, and as it happens, my own introduction to linguistics.

2 For careful review and analysis of the early period discussed briefly here, then on to the 1990s, see Freidin (1994).

3 In fact, Hockett dismisses this question as irrelevant to linguistics: "a string assembled by consciously violating the patterns of a language, like Chomsky's (1957) *colorless green ideas sleep furiously*, read forward or backward, is equally unimportant for linguistic purposes: it is fully explained when we understand how Chomsky produced it, and for what purposes" (p. 74).

4 Or elsewhere, as "the totality of utterances that can be made in a speech community," ideas that do not seem compatible (Bloomfield 1926).

5 There had, by then, been extensive work in generative grammar with specific proposals about what Hockett describes as "analogy, "abstraction," "pattern," also subjecting them to verification over a wide range of materials in many languages. Hockett does not allude to this work because it is all outside the range of science, according to his construal of the notion, to which we turn directly.

6 Elsewhere, Hockett proposes a framework that seems to resemble a generative grammar (Hockett 1954). Each of the models "sets forth principles by which one can generate any number of utterances in the language" (hence an unbounded number – a conclusion forcefully rejected in his 1968 monograph, as just noted). It is unclear how this result is achieved. The models assume a set of "constructions" (or "processes"), and an account of what can appear (or which processes operate) in each position. But apart from few examples, nothing is said about these core notions, which apparently are intended to be narrowly refined (e.g. conjunction/disjunction are different constructions). It seems, then, that a generative grammar is needed to spell out each construction/process, furthermore independent grammars for each of the positions in these entities. Similar questions seem to me to arise for contemporary Construction Grammar.

7 Quine dismissed the generative enterprise as "folly" on assumptions about "indeterminacy of translation" that he seems to have abandoned in a 1969 article in which he welcomes "any innate mechanisms […], however elaborate" (1969b, 307) in particular the "innate mechanisms […] that are needed in language learning" (1969a, p. 97) to yield generative grammars that "demarcate the right totality of well-formed English sentences" (1970, p. 388). It seems that his basic conclusions on indeterminacy of translation, inscrutability of reference, and others, have to be abandoned with these 1969 conclusions. Quine never reverted to the matter, which is also ignored in the extensive literature on Quine's thought, so it is not clear what to make of it. For further discussion, see Chomsky (1975). On Lewis, see Pietroski (2018).

8 Later, however, apparently abandoning it. See note 7.
9 On cognitive processes, see Roberts (2019). Of course, other cognitive processes play a major role in acquisition and use, separate matters. On neural factors, see the observations of Sandiway Fong cited in Chomsky (2020), which relate to interesting developments that I cannot review here.
10 On these matters as they were conceived from the earliest days of the generative enterprise, see Chomsky (2021).
11 The topic reached the research agenda with Lenneberg (1967). See Berwick and Chomsky (2016) for further discussion.
12 Note that narrow syntax excludes externalization. It yields structured expressions that should suffice for articulation of thought, if all further operations fleshing out the articulated thought are universal (or if there are none; on this possibility see Chris Collins, https://ordinaryworkinggrammarian.blogspot.com/2019/10/thought-as-syntax.html). That they are universal is generally assumed. This domain is conventionally called "formal semantics," but it should, I think, be regarded as part of syntax – symbolic manipulation – reserving "semantics" to domains that crucially involve reference/denotation. These properties do not appear to hold for human language (as distinct from the speech act of referring) in my opinion, for reasons extensively discussed elsewhere, a matter that would carry us too far afield.
13 For further discussion, see Chapter 1 of Chomsky (2016), Berwick and Chomsky (2016, Chapter 3) Chomsky (2019), Chomsky (2020).

References

Arnauld, A. and C. Lancelot [1660] 1975. *General and Rational Grammar: The Port-Royal Grammar. Translated by Rieux, J. and Rollin, B.E.* The Hague: Mouton.

Bar-Hillel, Y. 1971. Cybernetics and linguistics. In *Aspects of language: Essays and Lectures on Philosophy of Language, Linguistic Philosophy, and Methodology of Linguistics*, 289–301. Jerusalem: Magnes Press.

Berwick, R. C., and N. Chomsky. 2016. *Why Only Us: Language and Evolution*. Cambridge: MIT Press.

Bloomfield, L. 1926. A set of postulates for the science of language. *Language* 2 (3): 153–164.

Bloomfield, L. 1933. *Language*. New York: H. Holt and Company.

Chomsky, N. 1965. *Aspects of the Theory of Syntax*. Cambridge: MIT Press.

Chomsky, N. 1966. Cartesian Linguistics: A Chapter in the History of Rationalist Thought. New York: Harper & Row. [Third edition, with fuller and improved translations. 2009. Cambridge: Cambridge University Press.]

Chomsky, N. 1975. *Reflections on Language*. New York: Pantheon Books.

Chomsky, N. 2007. Approaching UG from below. In *Interfaces + Recursion = Language?*, edited by U. Sauerland and H.-M. Gärtner, 1–30. Berlin: Mouton de Gruyter.

Chomsky, N. 2016. *What Kind of Creatures Are We?* New York: Columbia University Press.

Chomsky, N. 2019. Some puzzling foundational issues: The Reading program. *Catalan Journal of Linguistics Special issue*: 263–285. https://revistes.uab.cat/catJL/article/view/sp2019-chomsky

Chomsky, N. 2021. Simplicity and the form of grammars. Journal of Language Modelling 9 (1), edited by Roni Katzir and Ezer Rasin.

Chomsky, N. 2020. *UCLA lectures*. https://ling.auf.net/lingbuzz/005485.

Freidin, R. 1994. Conceptual shifts in the science of grammar: 1951–1994. In *Noam Chomsky: Critical Assessments*, edited by C. P. Otero, Vol. 1, 653–690. London: Routledge.

Harris, Z. S. 1951. *Methods in Structural Linguistics*. Chicago: University of Chicago Press.

Harris, Z. S. 1965. Transformational theory. *Language* 41 (3): 363–401.

Huybregts, M.A.C. (Riny). 2017. Phonemic clicks and the mapping asymmetry: How language emerged and speech developed. *Neuroscience & Biobehavioral Reviews* 81 279–294.

Hockett, C. F. 1954. Two models of grammatical description. *Word* 10 (2–3): 210–234.

Hockett, C. F. 1968. *The State of the Art*. The Hague: Mouton.

Jakobson, R. 1990. *On Language*, edited by Waugh, L. R., and M. Monville-Burston. Cambridge, MA: Harvard University Press.

Joos, M. 1995. Preface to vol I. In Readings in Linguistics I & II, edited by E. P. Hamp, M. Joos, F.W. Householder, and R. Austerlitz. Chicago: University of Chicago Press. [Abridged edition, drawn from 1956 and 1966 collections of American and European papers.]

Lenneberg, E. H. 1967. *Biological Foundations of Language*. New York: Wiley.

Lewis, D. 1975. Languages and language. In *Language, Mind, and Knowledge, Minnesota Studies in the Philosophy of Science, Volume VII*, edited by K. Gunderson, 3–35. Minneapolis: University of Minnesota Press.

Miller, G. A., and N. Chomsky. 1963. Finitary models of language users. In *Handbook of Mathematical Psychology, Vol. I,* edited by R. Duncan Luce, R. R. Bush, and E. Galanter, 419–92. New York: Wiley.

Pietroski, P. M. 2018. *Conjoining Meanings: Semantics Without Truth Values*. Oxford: Oxford University Press.

Quine, W. V. O. 1953. *The problem of meaning in linguistics. Reprinted in From A Logical Point Of View: 9 Logico-Philosophical Essays, 47–64*. Cambridge, MA: Harvard University Press.

Quine, W. V. O. 1960. *Word and Object*. Cambridge: Technology Press of the Massachusetts Institute of Technology.

Quine, W. V. O. 1969a. Linguistics and philosophy. In *Language and Philosophy: A Symposium*, edited by S. Hook, 95–98. New York: New York University Press.

Quine, W. V. 1969b. Reply to Chomsky. In *Words and Objections: Essays on the Work of W. V. Quine*, edited by D. Davidson, and J. Hintikka, 302–311. New York: New York University Press.

Quine, W. V. O. 1970. Methodological reflections on current linguistic theory. *Synthese* 21 (3/4): 386–398.

Roberts, I. G. 2019. *Parameter Hierarchies and Universal Grammar*. Oxford: Oxford University Press.

Yang, C. 2013. "Who's afraid of George Kingsley Zipf? Or: Do children and chimps have language?" *Significance* 10 (6): 29–34.

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